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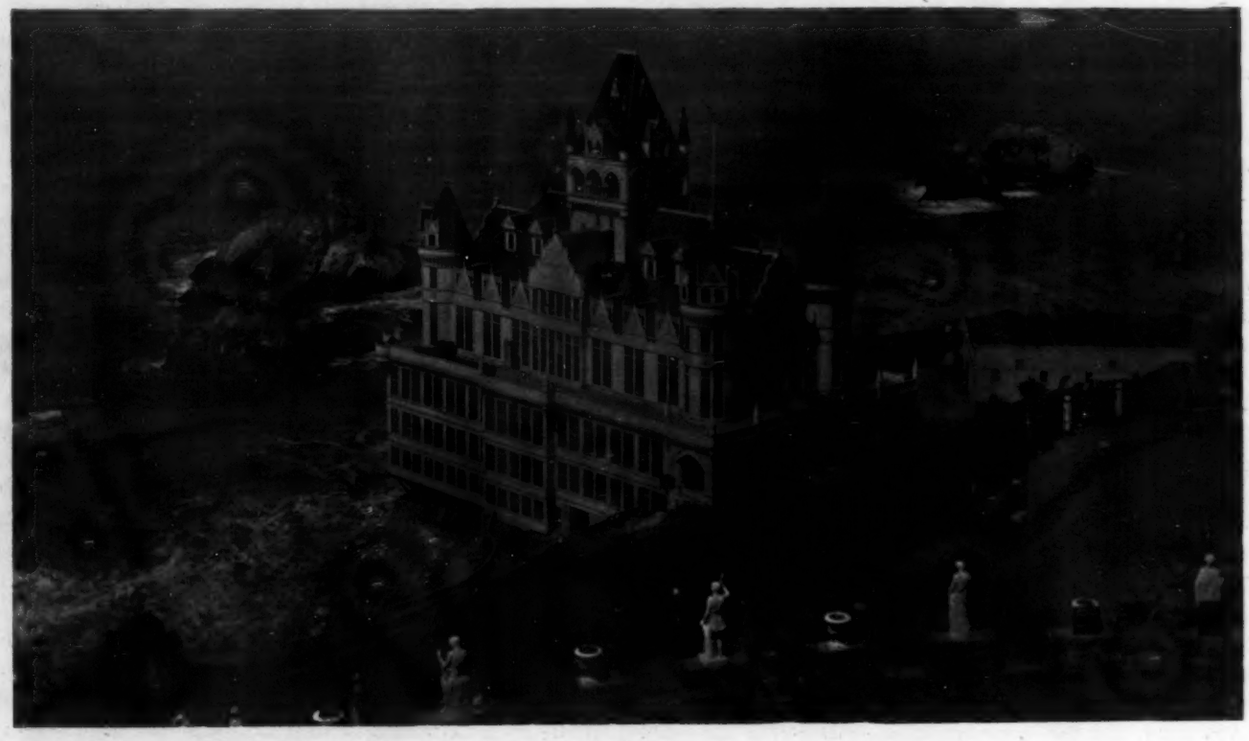
THE JOURNAL OF ELECTRICITY.

VOLUME VI. SAN FRANCISCO, JULY, 1898. NUMBER 1.

*Random Notes on Extremely High Potentials.**

BY LEON W. BLY.

SOMEWHAT of mystery, even to transmission engineers, exists concerning what is now termed extremely high potentials—that is, pressures ranging from 30,000 volts and upwards—and the fact is that very few men have had any actual continuous experience with potentials higher than 20,000 volts, while with very few exceptions, experiences have been limited to the operation of pressures ranging from 10,000 to 15,000 volts. Nevertheless, experiments with extremely high potentials as defined, have been quietly prosecuted west of the Rocky Mountains with a thoroughness that has undoubtedly been unequaled elsewhere, for as early as in the summer of 1896 power was effectually transmitted over a two-mile circuit under a pressure of 60,000 volts. The results, however, have been carefully guarded, and very little, if any, of the details of the important and expensive tests then made have been given to the public. Efficient and reliable generating and distributing apparatus of different makes can be found in the market, but for long distance work, the all-important and most difficult problem that confronts the engineer is that which leads to the determination of the highest voltage that it is practical for him to use after taking into consideration the loss of power, the cost of line and transformers, and the liability of interruption to service from the breaking down of either transformers or line. The difficulties attending the long distance transmission of power of extremely high potential, must therefore be laid at the door of these two most important and really vital parts of the equipment, namely, the transformer and the line, and it is under these two heads that the random observations brought out in this paper naturally resolve themselves.



THE CLIFF HOUSE, SAN FRANCISCO.

WHERE THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION HELD ITS SECOND ANNUAL CONVENTION.

Some electrical manufacturing concerns express willing-

* A paper read before the Second Annual Convention of the Pacific Coast Electric Transmission Association, held at San Francisco, Cal., June 21, 1898.

ness to build transformers for pressures as high as 50,000 volts, professing to guarantee them, but I think it will be found that these guarantees will not be of a satisfactory nature for pressures above 35,000 volts; at least this is a rational conclusion from the fact that no manufacturing company has installed transformers that are in practical operation at these pressures in regular commercial work. Where every effort has been made to secure such satisfactory guarantees, the buyer eventually finds that he must assume responsibility for the success of the undemonstrated experiment he undertakes in insisting upon the use of extremely high potentials, as the manufacturing company will take no responsibility for loss of business or other damages resulting from breakdowns. While it may be generally believed that these high pressure transformers are a comparatively unreliable piece of apparatus, a proof of what they are capable of doing is demonstrated by the 40,000-volt transmission over the thirty-two mile line between Provo Canyon and Mercur, Utah, which has been in successful operation since early in March last. A description of this interesting transmission will be found in THE JOURNAL OF ELECTRICITY for June, 1898.

To effectually insulate is, of course, the most important feature in high tension transformer design and building. The problem presented therein with commercial transformers operating at 60,000 volts, is by no means an easy task, and the success attained will depend largely on actual experience drawn from long and practical observation in transformer manufacture and operation. Believing that information along this line will be of value, I will endeavor to give a few points concerning features that I consider to be of good practice in attaining the highest insulation in this class of apparatus.

The suggestions offered are the results of practical observation and experience under actual working conditions, which has taught well the lesson that the installation and operation of transformers under these pressures are exceedingly sensitive and difficult, especially when the requirements for high efficiency necessitate such compactness of design as to throw serious obstacles in the way of attaining high insulation. I contend that the accomplishment of extreme high efficiencies in transformers of this class is not desirable at all times, for its attainment is only accomplished at the expense of reliability. The reason for this is simple: the highest efficiency in transformers is secured when the iron and copper circuits are of the least possible length, or in other words, when the insulating space is reduced to the least possible degree. The requirequirements for high insulation necessitate a form of construction that will give a high safety factor to the dielectric between coil and coil and each coil and the core, taking full consideration of the potential difference existing between these parts. I repeat, therefore, that the additional gain of say, of one per cent. in transformer efficiency is attained only through the serious impairment of its insulation, which in this case, is synonymous with unreliablity, and that, conversely, the loss of one per cent. in transformer efficiency is apparent and not real when it is the direct means of cutting down the line loss from, for instance, ten per cent. to five per cent. In other words, transformer and line losses in all transmission work, should be considered collectively and not individually. To emphasize this point still further it may be stated that a transformer delivering 60,000 volts will have an efficiency that is one per cent. lower than a transformer delivering 30,000 volts, but by doubling the voltage delivered, we have secured a line loss of but twenty-five per cent. of that which would exist were the lower voltage applied to the same line. Further comment on the necessity for attaining the maximum efficiency of the transmission system as a whole, rather than of the transformer as a separate factor, appears unnecessary.

Oil is indispensible as an insulating medium in extremely high pressure transformers, principally because of its much greater resistance to discharge than is possessed by the dielectric properties of air. As a rough example, one-eighth of an inch of mineral seal oil will require, with an alternating current of sixty cycles, a little over 20,000 volts to puncture it, which is, perhaps, six or eight times the potential required to jump across an air gap having the same separation. Right here may be stated the conviction that the use of air is impracticable as a medium of insulation on high tension transformers.

The space surrounding high tension coils as well as the insulation between turns and layers, should be laid out with a liberal safety factor for the difference in potential at that point. A very good practice in this regard is that used on some high pressure transformers recently placed in operation in which the coils were set upright, that is, the iron openings were placed in a vertical position, as were also the insulating strips, in order that the circulation of the oil may be facilitated. Some temperature tests on these transformers show the temperature to be fairly uniform throughout. Hard wood, such as maple or walnut, when properly treated with the oil used in the transformer, forms one of the best materials that can be used to support the coils; in fact where a solid insulation must be used within transformers, wood is the best material, as it not fragile, is easily worked into any desired form, and it is a good insulator for high pressures when immersed in oil.

The bringing out of terminals constitutes another difficult feature in the transformer building, and heavy insulation such as glass or porcelain tubes are desirable, while for the terminal block again wood forms the most serviceable material as it is far superior to marble. It is advisable, however, that the terminal block of wood should be under the surface of the oil, especially if the terminals are numerous, or exposed to high potential differences. In taking the terminals out through the tank it is advisable to lead them through the top, care being taken to avoid the case, and to keep the high tension and low tension terminals well separated. Some manufacturers favor bringing the low tension leads out through the side of the tank, which is commended. The necessity for taking the high tension terminal through the top of the transformer is evident, for the reason that in so doing there is less liability of personal injury by contact. The

leads may be more easily given the wide separation that is necessary when carried through the air; the terminals may be carried up through glass or porcelain tubes incased in wood set into the top of the tank, and a wide area of insulating material may intervene between the terminals and the tank cover so that sparking over from terminal to tank will be prevented.

Fullerboard forms one of the most desirable materials that are used in transformer building on account of its uniformity of surface and insulation. It is easily fitted any desired shape; it is flexible; it may be obtained in large sizes, which makes it superior to mica, and it is an excellent insulator.

It is of course necessary to divide the high tension coils up in many sections in order to reduce the difference in potential between the layers, and yet, sometimes it has been found that after splitting up the coils, trouble was experienced from the sparking over at the ends of the coils between the layers. This difficulty is overcome by the ingenious design of some high tension transformers recently constructed, in which a strip of insulating material consisting of a cotton cord of the same diameter as the wire, was wound on the edge of either end of each layer, thus preventing a discharge across the end of the insulation separating the layers. My observation has led me to believe that many unaccountable breakdowns of high tension transformers is the result of carelessness in properly assembling and holding into place. Muslin seems very desirable for use in binding together the coils as well as wrapping them before binding them together, to hold all insulation between turns, etc., in place. When some solid insulation, such as fullerboard, is used in addition to the oil and other insulation surrounding the coils, it is no doubt a very good practice to let it extend well out beyond the edge of the coils, as it might prevent any piece of conducting material, accidentally getting into the transformer, from causing trouble.

When oil is used, one can take advantage of its heat conducting properties to get larger radiating surface by properly corrugating or in some way increasing the surface of the tank, and so be able to dispense with extra appliances for cooling. But where it is found necessary to use water coils for cooling, the proper place for the coil is near the surface of the oil, and not extending through to the bottom of the tank as is the practice of some manufacturers, for the reason that, as the hot oil rises to the top, the cooling coil should be placed at the top where its influences are desired, and not extend through to the bottom, which makes the whole transformer relatively cooler. The latter practice causes the transformer to work under uneven temperature.

Another error which the experimenter in extremely high potentials is liable to fall into is in the design of the building for the high tension apparatus. A liberal allowance in space for high tension leads, switches, lightning arresters, and long break switches should be made to eliminate possibility of trouble, and where high tension leads are taken through walls of buildings, they should be carried through insulating panels with ample separation between the wires. I believe the practice of taking line wires out from stations through such panels to be superior to the ordinary mode of leading them out through openings in the wall, for the reason that by enclosing the openings and putting a gable over the enclosing panels, the insulating supports of the high tension circuits within the building are freed from the insulation impairing proclivities of the outside atmosphere. These insulating supports are necessarily closer together within the building than is required in outside work, hence the necessity for giving them greater protection against the atmosphere.

A consideration of the features of transformer design and operation would be incomplete without reference to the protection of transformers from lightning, but as my experience has been limited to but one form of arrester, namely, the Wurts, I do not feel qualified to discuss the qualifications of the various types; nor could I add to the literature existing on the subject. I must acknowledge, however, the comparative success that has attended the use of these arresters on the extremely high potential lines that have come under my observation.

The subject of transmission lines has proven a fruitful source of discussion, and many of the details of line construction have settled into such well defined lines of efficient practice that they do not appear susceptible of material improvement. Details of line calculation and of mechanical features, however, are points upon which little can be said that is new, but the practical experience of those who have handled the extremely high potentials with which this paper deals, is that the electrical transmission of energy at the higher potentials necessitates considerable difference in practice from the transmission of potentials ranging between 10,000 and 20,000 volts. Some of these differences will now be briefly touched upon.

As to insulator materials, porcelain punctures more readily than glass, and in addition, it is becoming realized that the porcelain within an insulator may be considered as forming a solid well suited for the support of the insulating glaze; glass, however, is homogeneous throughout, its puncture resisting qualities are high, and withal, when first cost is considered, glass forms an insulator which is preferable to porcelain, if the fact of its more general use on transmission lines is accepted as conclusive. Leaving out the respective merits of glass and porcelain, however, the prime qualification of a reliable insulator for extremely high potentials may be summarized in general as mechanical strength, largest possible dry surface between wire and pin, and of puncture resisting material. To my mind, however, so much attention has been given to the study of the design and characteristics of insulators that the importance of the equally vital device found in the supporting pin has been largely overlooked. As a result, the insulator has approached a fair degree of perfection, but the pin has been more backward in its development. I want to emphasize the belief that, in extreme high tension work, it is a grave mistake to consider the pin as any other than an integral part of the insulator. It is not a part of the cross arm, and being a

part of the insulator, it must be of the best insulating material suitable for its purpose. In fact, the pin possesses an importance almost equalling that of the insulator itself, and any feature which impairs the qualities of the pin as part of the insulator, seriously weakens the permanence and reliability of the line.

It is for this reason and others, that my experience has led me to look with distrust upon all supporting pins consisting of or containing iron bolts. These iron pins are used only to give added mechanical strength, but they accomplish this at the cost of introducing a conductor into the weakest part of the insulator, inviting puncture and the troubles consequent thereto. Puncturing and the burning off of pins at the point opposite the lower edge of the inner petticoat, constitute the two serious troubles to be looked for, and the occurrence of both these troubles may be attributed to the fact that the supporting pin is of conducting material. Many efforts have been made to produce an insulator giving a high resistance to puncture, and porcelain base pins have been introduced to prevent the burning off of pins, but to my mind it would be greater wisdom to remove the cause of the trouble—the conducting pin—than to attempt to devise a remedy for it while still permitting the cause to exist. To carry a steel pin clear up into the body of the insulator maintains a constant invitation to puncture. The easiest way to accomplish a thing is the best way; and I believe that the elimination of troubles due solely to the conductivity of pins, may be effected satisfactorily by substituting strictly non-conducting pins for pins that conduct high tension currents in stormy weather. Prepared wood pins have been found to be very satisfactory for extreme high tension work.

Bearing in mind that the pin is a part of the insulator and not of the cross arm, it may be said that the chief qualifications of the insulator are, first, ample width to keep the pin and under petticoats as dry as possible; second, ample separation or elevation from the cross arm to prevent leakage from following the drops of moisture; and third, ample dry surface in corrugations around the crown of the insulator—in addition to the dry surface on the inner petticoats—to break the circuit formed by moisture or rain from line direct to cross arm. These qualifications should be combined with mechanical strength and durability.

In practice it has been found that the separation between transmission lines is not done with the idea of preventing short circuiting or cross leakage so much as it is to reduce the capacity of the line, and in extremely high potential work the difficulties consequent to increase in capacity will be found of constantly increasing seriousness as the potential raises, and the most efficient mode of reducing capacity is by separating the lines. The effect of capacity may develop into an important factor and demands careful attention, especially on extremely long lines at extremely high potentials. By introducing a reactance into the circuit, this can be practically neutralized, but a system thus balanced and containing great capacity and reactance, may be very difficult to regulate, as its balanced condition will be affected by many factors, some of which are uncontrolable. For instance, a change in the load, or a change in the power factor of the load, or a change in the atmosphere, will affect its unbalanced condition.

Much further might be said concerning work of this class, but I will only add that with whatever elaboration the functions of an extremely high potential transmission line may be figured out, the installation when completed will prove that no exact dependence can be placed on the theoretical deductions, for the reason that the factor of capacity is one that varies with practically every atmospheric change, and more especially with the influences on capacity from varying power factors due to changes in load.

I must add, in conclusion, that the treatment of what may be called the phenomena of extremely high potential practices, which, in a very superficial way, is what this brief paper is intended to be, should not be confounded with experiences had in the operation of the lower potentials of from 10,000 to 20,000 volts. As intimated, the opinions here given are mainly of a general character, for the present paper only sets forth a few random observations on extreme high potential workings.

*On the Electrical Operation of Conoidal Centrifugal Pumps.**

BY JOHN RICHARDS.

CENTRIFUGAL pumps as water impelling apparatus, lend themselves especially to electrical transmission of power because of rotary movement, high speed of rotation, and almost complete immunity from derangement; also an efficiency, that, if facts are considered, exceeds that of other pumps that would substitute the centrifugal type. To these features can be added a lower first cost and maintenance. These last named features, arising principally out of the conditions of a continuous flow, bear an astonishing relation to reciprocating or piston pumps and is not more than one-fourth as much for a given volume of water; the cost of foundations is usually in the same proportion, so that for large volumes of water raised to moderate heights, there is scarcely comparison between the two systems of pumping. These being the advantages, I will now revert to some impediments that rise in the adaptation of centrifugal pumps to be driven by electric motors.

These impediments are: a constant duty, variable only within narrow limits, and a desired speed of rotation beyond what the hydraulic and constructive conditions permit. If there are other impediments that apply to centrifugal

*A paper read before the Second Annual Convention of the Pacific Coast Electric Transmission Association, held at San Francisco, Cal., June 21, 1898.

pumps I am not aware of them, and I will now proceed to show that even these can be removed.

The first one, variable duty, when we come to consider it, is one that need not exist, because without even increasing the original cost, and with certain operative advantages, a pumping plant can be adapted to all practical requirements of a variable duty by subdivision into units.

In 1897 I prepared plans for pumping stations to be erected in New Orleans, by the Drainage Commission of that city, and as nearly all these pumps, requiring in the aggregate more than 10,000 horse power, were to be driven by electric motors, every phase of the subject came under consideration.

The heads varied from three to fourteen feet, and the volume included, besides seepage, the rainfall on about twenty-five square miles. The problem of electric transmission came up two years earlier, but would not, at first, be entertained by the Drainage Commission because of its novelty. Mr. Charles Brown, of Basel, Switzerland, who acted as my colleague in the preparation of plans for the hydraulic elements, strongly recommended the electrical method and submitted the conditions to Messrs. Brown, Bovrie & Co., of Baden, Germany, who, with Mr. Brown, Sr., made comparative estimates, including land areas, maintenance, fuel, water for condensing, the danger of fire, effect on insurance rates, cleanliness, and indeed all the various conditions, and decided that the circumstances were much in favor of electrical transmission.

The Drainage Commission, of which Major B. F. Harrod, U. S. A. Engineer Corps, is chief, came to the same conclusion in 1897, and then arose the subject of the variable duty which was an extreme, varying in a degree such as is never met with in other works of the kind; for example: twenty to one, or even more than this. But what at first seemed a formidable impediment entirely disappeared when we finally came to arrange the pumping stations. We simply divided them into units of 50 to 100 cubic feet per second, and found that the estimate was not increased, but was actually reduced by such subdivision.

I have taken some space to explain this matter, because the same conditions come up in nearly all cases when water is to be raised for irrigating purposes. The limits for economical subdivision are easily computed. If twenty cubic feet per second is to be raised, the cost of four pumps and motors, each of five cubic feet capacity, operating independently, will not be more than for one pump and motor of twenty cubic feet capacity, and when less than the maximum volume is pumped it must be remembered that conduit friction is almost eliminated by the low velocity of flow in the main pipes. When single pumps of small size are to be employed, throttling the discharge is perhaps the best means of regulation. The surplus water can be returned or circulated, but in either case the power consumed will be the same as for full duty, because the resistance of a throttling valve in either case must equal the discharge pressure. It is preferable to subdivide down to one or two cubic feet per second.

On the subject of pump design and speed of rotation, as already stated, the circumstances at New Orleans were extreme ones, and demanded a complete departure from common practice. The impellers in some cases, owing to the low heads, become smaller in diameter than the bore of the inlet pipes, and this led to the adoption of what I have named the "conoidal system" of construction, wherein the impellers are widened to any extent desired and still have a uniform and complete action at all points of these width.

To render this matter more clear I include with this paper a section and side view, also an elevation, of a pump on the conoidal system, arranged in accordance with the following quantities:

Capacity in cubic feet per minute	360
Head of water in feet	35
Revolutions per minute	1000
Efficiency (per cent. of power)	50 to 65
Horse power required, gross	40
Area of pipes, in inches	100
Approximate flow, feet per second	8

This, you will perceive, is an easy problem for a pump mode on the conoidal system, the impeller being in diameter as 13 to 9 of the bore of the suction pipes.

This form of construction, the subject of recent patents in this country, is not, as might be inferred, a simple widening of the pumps and reducing their diameters to permit a higher speed of rotation. The essential feature is the attainment at all points in the width of the impeller and uniform action and a change of the course of the water by easy curves, thus retaining all the efficiency possible in pumps of the regular construction.

This, as may be seen, disposes of the impediments of speed and permits in any case the employment of motors of economical adaptation; that is, of high rotative speed and small dimensions in proportion to their relative power.

I am not aware how far this system of conoidal impellers can be applied to very small pumps. Thus far designs have been made for pumps from 4 to 117 cubic feet per second, with pipes from 10 to 60 inches in diameter. I fully expect, however, that it will carry out, mechanically and economically, down to the smallest sizes, the general design being as shown in the present elevation. I may also state that it is the intention to adopt it in future practice for other than dredging and special pumps.

TO REDUCE GENERAL ELECTRIC SHARE CAPITAL.

THE directors of the General Electric Company have voted to recommend to the stockholders a reduction in the share capital of the Company, both common and preferred, of forty per cent., so that each holder of one hundred shares of present stock will get sixty shares of the new stock. This settlement, while satisfactory to the common stockholders, is regarded as particularly favorable to the preferred shareholders, inasmuch as it will render unnecessary the taking of any steps for the liquidation of the Company, in which event the preferred stockholders would receive only the same amount as the common stockholders, and no back dividends. The plan now adopted contemplates the payment, from the surplus earnings of the Company as they are hereafter made, of the accrued dividends on the preferred stock. On the basis of the new capitalization, $1,275,000 will be required annually to pay seven per cent. upon the preferred stock and six per cent. upon the common stock.

Proceedings of the Second Annual Convention of the Pacific Coast Electric Transmission Association, held at San Francisco, June 21st, 1898.

WHOEVER it was that "discovered" the world-famed Cliff House, at San Francisco, as a place for holding conventions, conferred a boon upon convention-going society, for a more admirable location could not have been selected than the one chosen for the holding of the second annual meeting of the Pacific Coast Electric Transmission Association on Tuesday, June 21st. The service and cuisene are excellent, the assembly room is luxuriously furnished for such occasions, and its site, with the mighty Pacific thundering at one's feet, is incomparably inspiring. Then the Cliff House, while in San Francisco, is sufficiently distant from the commercial centers to avoid interruptions of a business nature, and so it was that the executive session of the Association therein at 2:30 p. m., the open convention at 3 p. m., the dinner at 6 p. m., and the continuation of the open meeting at 8 o'clock, proved very profitable and highly enjoyable.

The members present at the executive session consisted of the following companies: Blue Lakes Water Company, represented by N. Randall Ellis; Central California Electric Company, by Dr. C. Van Norden; Sacramento Electric, Gas and Railway Company, by C. P. Gilbert; San Joaquin Electric Company, by J. S. Eastwood; Southern California Power Company, by O. H. Ensign; Standard Electric Company of California, by Wm. Angus; and the Yuba Power Company, by F. V. T. Lee. President C. P. Gilbert occupied the chair, with Robert McF. Doble as Secretary.

After the reading of the report of the secretary and treasurer, which showed the affairs of the Association to be in a thoroughly satisfactory and prosperous condition, the membership of the Association was increased by the election of the following:

Honorary member—F. A. C. Perrine, D. Sc., professor of electrical engineering, Leland Stanford Junior University, and electrical engineer-in-chief of the Standard Electric Company of California.

Member—Standard Electric Company of California.

Associate Members—A. E. Brooke Ridley, Pacific Coast agent Siemens-Halske Electric Company of America; S. N. Knight, President Knight Water Wheel Company; The Westinghouse Electric and Manufacturing Company; Edw. S. Cobb, of Cobb & Hesselmeyer, mechanical and hydraulic engineers; Pelton Water Wheel Company.

Officers for the ensuing term were then elected as follows:

President—Mr. W. Frank Pierce, President of the Blue Lakes Water Company.

Vice-President—Mr. Carroll N. Beal, Secretary and Treasurer of the Power Development Company.

Secretary—Mr. Geo. P. Low, editor and proprietor of THE JOURNAL OF ELECTRICITY.

Treasurer—Mr. William Angus, Secretary of the Standard Electric Company of California.

The above officers, with Dr. C. Van Norden, President of the Central California Electric Company, constitute the Executive Committee for 1898-99.

At the conclusion of the executive meeting, the second annual convention of the Association was called to order in open meeting, those present being:

Angus, Wm., Standard Electric Company of California, San Francisco.

Babcock, A. H., Standard Electric Company of California, San Francisco.

Brown, Frank L., Washburn & Moen Manufacturing Company, San Francisco.

Burkholder, W. A., Westinghouse Electric and Manufacturing Company, San Francisco.

De Sabla, E. J., Jr., Nevada County Power Company, Nevada City, Cal.

Doble, Robert McF., Abner Doble Company, San Francisco.

Dutcher, C. E., Finance and Construction Company, San Francisco.

Eastwood, J. S., San Joaquin Electric Company, Fresno.

Ellis, N. Randall, Blue Lakes Water Company, San Francisco.

Ensign, O. H., Southern California Power Company, Redlands.

Gilbert, C. P., Sacramento Electric, Gas and Railway Company, Sacramento.

Hutton, C. W., Sacramento Electric, Gas and Railway Company, Sacramento.

Lacy, B. T., Parke & Lacy, San Francisco.

Lee, F. V. T., Yuba Power Company, San Francisco.

Lighthipe, J. A., General Electric Company, San Francisco.

Low, Geo. P., THE JOURNAL OF ELECTRICITY.

Mooney, S. V., J. A. Roebling's Sons Company, San Francisco.

Ridley, A. E. Brooke, Siemens-Halske Electric Company, San Francisco.

Sedgwick, C. E., General Electric Company, San Francisco.

Sinclair, H. H. Southern California Power Company, Los Angeles.

Van Norden, Dr. C., Central California Electric Company, Sacramento.

Van Frank, E. M., Sutro Railway Company, San Francisco.

Walker, Geo. D., Washburn & Moen Manufacturing Company, San Francisco.

Warren, H. S., Blue Lakes Water Company, San Francisco.

Wybro, H. C., Walker Company, San Francisco.

A full report of the transactions of the convention appears below, President Gilbert opening with the following remarks:

THE PRESIDENT: The meeting will now come to order in open session. Your President will spare you and the Convention from a President's address. Better material, I hope, has been provided, but a brief statement of the motives of this organization, and the progress made during the past year will, I hope, be in order.

The object of the Association is stated quite concisely in the by laws, and need not be repeated. It has for its precedent the National Electric Light Association and the Association of Edison Illuminating Companies, which have grown from small and somewhat uncertain beginnings, to be important features in the electrical industries in the East. Situated as the membership of this Association is, off the line of travel of eastern electrical interests, we are more dependent upon each other than they, and at the same time, being scattered over a coast line of over 1200 miles, association with each other is more difficult than among the electrical companies of the more thickly settled East.

This organization began with a pledged membership of ten, and has, during the year, increased to a total membership of fifteen, as it stands today. Sessions have been held at Santa Cruz, Sacramento, and San Francisco, it being part of the plan, as outlined at the organization, to hold quarterly sessions, visiting the different plants on the Coast. The papers read at these several meetings have, I believe, proved of great

value to the members in bringing under discussion between representatives of operating companies, manufacturers and experts, electrical problems and experiences drawn from actual commercial practice, and I believe that all who have attended the meetings realize the possibilities of such an organization as this, in enabling operating managers, working in a new field, to avoid the mistakes made by others, as distinguished between the defects of design and defects of construction, and in the bringing into close touch the allied interests of operating plant manufacturer and expert. Such has been the aim of your officers, and such success has been attained as to justify the prediction that the Pacific Coast Electric Transmission Associatian can be made an important factor in the electrical industry of the Pacific Coast.

We will now call upon Mr. Low to read a paper written by Mr. Bly, who, unfortunately, is not here to read the paper for himself, and who has asked Mr. Low to read it for him.

Mr. Low reads the paper by Mr. Bly, appearing on page 5.

THE PRESIDENT: Mr. Bly's paper has doubtless suggested many points of criticism. I ask Mr. Lighthipe for his opinion regarding the points on insulation there given, as some of them are, to my mind, perhaps a little novel, and no doubt Mr. Lighthipe will be able to call attention to other points.

OIL INSULATING VERSUS AIR COOLING.

MR. LIGHTHIPE: When we drop oil we adopt a new type of transformer that need not be kept enclosed—simply a type that we can drive air through. Our factory experiments have led us to abandon oil for high potentials, hence our experience is the opposite from the opinion expressed in the paper. We often find a certain amount of trouble in using oil, probably due to impurities, and it has been brought out by Professor Thompson, I think, that impurities in the oil will follow certain lines and gradually build a bridge of lower resistance than that of the rest of the oil, and while oil is a good thing to prevent puncture and to cover up punctures after they have been made, if we can do without it, we can build a type of transformer giving more room and more chance for cooling, and one that will give less trouble with the terminals coming out. My personal experience in oils, beyond the pressure of 2000 volts, is limited.

THE PRESIDENT: I asked the question under the impression that the recommendation made in the paper was contrary to the practice of the General Electric Company in regard to oil insulation for high voltages. It has been my impression that the use of oil was one of the main dependents in using high voltages.

MR. LIGHTHIPE: The point was very well taken in regard to efficiency. As we run the high potential up, of course we have to make the air gap larger and larger, to protect ourselves, and as you increase the air gap you increase the C^2R losses on account of the extra copper, and at the same time run the efficiency down on account of the increased air gap in the magnetic line. So that I think the point is very well brought out that the transformer efficiency must not be the single thing to consider. If we want to raise our potentials, if we can change our loss on the line from ten per cent. to five per cent., we can just as well have one or two per cent. of it in the transformers, and build them safe and reliable. But I am not in position to debate on the question of oil at all. I don't know very much about oil. We are drifting away from oil.

MR. ENSIGN: Regarding the use of oil in transformers, there are, no doubt, some advantages in its favor in the matter of size and weight, but it seems to me that when you come to fill up a case with oil, or with any substance where you cannot give thorough inspection to the transformer, you so submerge the insulating substance into the oil, that even if you could take it apart to examine it, you cannot get at the parts because they are smeared with something which you cannot find. It is quite easy sometimes to patch a transformer if you can locate the trouble, but with oil you cannot locate it, because oil, it always appeared to me, is over all the work. I had occasion to take apart a 250-light transformer, in which this point was brought out very plainly. All over the edges of the coil, and on the corners of the iron, was piled up a sediment. It was unaccountable how it got there. It did not look like dust. It had no grit to it, but it was a thin material, which was, considerable of it, supported in a buoyant state—held in the oil itself.

For myself, I saw some machines last summer that were given a high potential test, and so far as the matter of insulation is concerned, I believe it can be gotten quite as well without oil as with oil. One of these machines had a stationary armature of twenty coils, having an internal diameter somewhere in the neighborhood of twenty-four feet. It was insulated to stand for six minutes at a test of 30,000 volts. The higher or the greater the surface between the iron and the copper—the higher the condenser action which takes place—the higher the capacity, the more difficult it is to maintain those insulating properties. Those machines were built under such a guaranty as that, and they stood up to it. If they can do that with a large machine, and operate at 60,000 volts, it seems to me it can be accomplished in a transformer.

DR. VAN NORDEN: We have had considerable experience in the failure of high potential transformers, but we have received no light whatever, no explanation, unless that which has been given in the paper, that high efficiency has been sacrificed to insulation. We have had transformers that have broken down; but, very strange, there does not seem to be a jumping of the voltage across any distance, from one coil to another coil. As a rule, the individual coil breaks down, and the short circuiting is between the wires.

THE PRESIDENT: Were those transformers oil transformers?

DR. VAN NORDEN: Yes, oil transformers, and as a rule, when we take them out we have no trouble whatever in taking them to pieces. We don't have the trouble the gentleman spoke of, of finding it impossible to discover the fault. Some times the fault is inside the coil entirely. Our conclusion is that it is some kind of a static phenomenon. The company which supplies the transformers seems to be unable to account for the facts. We thought for awhile that where there was a very great difference of voltage between two adjacent coils—there is a difference of about 7000 volts—we thought the current crossed that point, but we discovered that was a mistake, and if more than one coil was involved, it was because the thing went on too long, and in melting the copper, and so on, the other coil was affected, but that, originally, the trouble was inside of one coil. In one case it was the breaking down of the low potential side of a large raising transformer at the power house, where the voltage was between the two copper plates. There was not more than thirty volts difference in potential, and it arced across that. There seemed to be perfect insulation, and it melted these copper plates. Apparently the current jumped across from one plate to the other, and then the melting extended until perhaps five or six plates were affected. But why there should be the shortening across coils that had a difference of only fifteen to thirty volts potential, I could not understand, nor have I received from anyone any satisfactory explanation. It seems to be the opinion of those who are qualified to judge, that it was not a breaking down of the insulation, but some static phenomenon, the explanation of which is not forthcoming, so far. I want to say that for quite a while we have had no trouble with our transformers.

THE PRESIDENT: I would inquire if Dr. Van Norden's experience has suggested any other in that line. Mr. Hutton, have we had any experience in connection with that which Dr. Van Norden has been taking up?

MR. HUTTON: There has been nothing like that; that is,

from coil to coil. We had some insulating bushings where the high potential leads ran to the transformer. By dust accumulating on these, the current followed the dust and jumped across, setting the transformer on fire, but we have had nothing in the shape of jumping from coil to coil or layer to layer. The trouble with those bushings constitutes the only experience we have had of trouble with high potential transformers.

DR. VAN NORDEN: There seems to be an arcing with the high potential coils in some cases from one wire to the next. It begins inside the coil, and then continues from those two to the third, then to the fourth, and so passing right through the second coil, the wire melting as it proceeds. We have found the coils in various stages of this process. But ordinary insulation was on the wire, and there was almost no difference in potential between the wires.

MR. LIGHTHIPE: Considering this arcing from coil to coil, with a low potential of perhaps from thirty to one hundred volts, is it not possible that the fact that the oil was in there, and was not allowed to circulate, formed a bridge on the magnetic lines running across from coil to coil?

DR. VAN NORDEN: Oil could not get inside of the coils.

MR. LIGHTHIPE: Is not the coil immersed in the oil?

DR. VAN NORDEN: It is.

MR. LIGHTHIPE: The coil itself carries the oil in there, and the oil does not circulate.

DR. VAN NORDEN: Do you think the oil is between the wires inside of the coil?

MR. LIGHTHIPE: I think it is all through.

DR. VAN NORDEN: It is a cotton insulated wire, shellacked, then covered with muslin and shellacked, and then covered with paper. So I don't see how the oil could get between the wires.

MR. LIGHTHIPE: I think on taking them apart, you will find the oil completely inside. The point I was trying to bring out was that unless we have an oil that is chemically pure, which is almost an impossibility with the commercial oil used, we are liable to use oil with all sorts of foreign substances and when we cannot keep the oil in constant circulation, the foreign matter in the oil will follow along certain lines of force and stay there and "bridge" across. In does not take much of a bridge to start an arc. Very little bridging will start the arc, even if there are only fifty volts between.

The point that Mr. Ensign brought out I think is very good. Where the transformer is get-at-able, you can clean it thoroughly with an air blast of thirty or forty pounds to the square inch. With oil you have simply got something—you don't know what—going on in there, and after it has broken down and been taken apart, the healing properties of the oil of covering up a rupture have probably covered up all traces of the trouble, and if we can get anything like equal results on high potentials without the use of oil, we have so many more advantages in the get-at-ability of the transformer, in watching it—and they do all need watching and keeping clean—that it seems to me that if it is possible to do without oil, and still get the high potentials, something is had that can be handled much better.

DR. VAN NORDEN: How would that bear upon the efficiency?

MR. LIGHTHIPE: I think the efficiency will be just as high. We all know that oil is good, better than air, but that air keeps the transformer cool, requiring no external device. We can blow air through as fast as we like, with a very small amount of energy, and there is nothing like a good draft of air to keep things cool. The main point about air transformers that I like is that they are not all buried up; they are accessible. It is like cable in the power house; no matter how well we insulate it, and put it down in conduits, we old people at the business don't like to see that wire buried, no matter how well it is buried. It can be buried in concrete or cement, or anything you like, but we always like to have it where we can get at it at any time. I would like to see every wire in buildings and power houses so placed that you can get at them if you have to.

MR. ENSIGN: Regarding the matter of efficiency, so far as I can understand the transformer design, you can make the efficiency what you please if you put the proper bulk in it. If you have to allow air space, you make your transformer that much heavier, and get the same efficiency that you have when you have lowered the insulating space.

MR. LIGHTHIPE: Mr. Ensign is perfectly correct.

MR. LEE: Our experience with the method of insulating and cooling transformers has led us to the conclusion that all different types have their proper use. Our company builds the self-cooling type, the air-cooled type, the oil-insulating self-cooling type, and the water-cooled, oil-insulated type. Taking the case of a small installation off the main line, where transformers are put in, it is usually out of the question to use the self-cooling type, because the size precludes it. If you cool with air you have to install a motor and fan, requiring some attention, whereas if you use the oil-insulated, water-cooled type, it is comparatively easy to have the water circulate, and but little water is necessary to absorb the heat. Where these transformers are used, they have a worm that encircles the transformer proper, and the water circulates through this worm. The oil surrounding this worm is kept at a uniform temperature, and the heat is dissipated. At the Yuba power house, just recently installed, we have the oil-insulated and water-cooled transformers, water for which is got from a little reservoir put in for fire purposes.

So far as the difficulty in getting oil is concerned, what Mr. Lighthipe says is true—that is, to get oil that will stand a high test and be chemically pure. I suppose this is commercially impossible. At the same time you can get oil for transformers that will do the work. Another feature about an oil-insulated and water-jacketed transformer in large units, is that the cost is a great deal less, which is often important. We can build a transformer, oil-insulated and water-cooled, cheaper than we can one of the air-cooled type. They are possibly a little more weighty, but they are very compact and have little to look after. No question of dust arises, because they are water-tight and hermetically sealed. The leads, as rule, come out through porcelain, and they usually wax them up to keep out dirt. If, however, you have a large station containing many banks, it is comparatively easy to get a circulation of air; but at the Marysville sub-station, and the Brown's Valley sub-station, men are not there all the time, and it would be necessary to have a fan going to circulate the air for cooling them, whereas in these sub-stations they have a small tank of water filled only two or three times a week, which gives enough water to cool the transformers.

MR. EASTWOOD: I have had some experience in the last few weeks in the transformer coils burning out. On coming from the mountains recently, I found we had lost one of our sub-station transformers. We put in an extra one and lost it also, and then we fixed up another one out of the two, and lost it. Yes, we have had some experience. I am happy to say, however, that we have made up a new one out of the wreck of the two we had left, and this transformer is still running.

A careful examination of our transformers, after running nearly three years, shows conclusively a point that has not been brought up, which is, that the insulations necessarily used in building transformers are perishable goods; that they have a limit of life the same as any other vegetable substance, and that when they are subject to the heat attending operations at a paying load, they are going to deteriorate very fast. Wherever there is a soldered electrical connection, the heat of twenty-four hour service will gradually cause a little of the solder to drop out, and every time you lose solder you are having a greater resistance between the parts of your

connection, and the greater the resistance the greater the heat, and so on, until you come to the arcing point, when you get into serious trouble. We have found that it is necessary to go over the terminals of all our transformers and re-solder the connections.

The transformer coils that we have lost so far, have broken down between the parts of the coil, which primarily starts in an arc and short circuits. It is my opinion that these breakdowns occur largely from the heat and the deterioration of the insulating material. Rubber does not last but about one season. You can take a rubber band and put it around a lot of papers and lay them away for one summer, and the next summer you can pick it off in pieces. All the material that we use in insulation is liable to become carbonized and to crack, and to open up in various ways, and the constant accumulation of dust that we cannot avoid in this country will drop into the cracks and cause a short-circuit in the coil.

In the matter of the use of oil in transformers, we find that in putting oil into a set of small transformers that we call our "Chinatown" set, for some reason or other the water that had accumulated on top of the barrel while it stood in the yard, had gone down into the barrel, and when the oil was emptied into the transformer, strange as it may seem, the water went into the bottom of the transformer, and we had trouble. The transformer burned out, and in taking it down, we had the same experience that has been noted by Mr. Lighthipe and Mr. Ensign—we couldn't find the cause of the trouble without a great deal of cleaning off and hunting. The transformer oil that we get, even the best of it, is not, I think, pure enough to form a good insulator, so that now all our transformers are put up without oil.

GIVING TRANSFORMERS A REST.

DR. VAN NORDEN: Is it any advantage to let these transformers rest and not work them all the time? We are going to arrange our transformers so that they can be switched in or out, always having one or two to spare, and we intend to use the spare ones in place of some that are at rest. We have an idea that it is going to be to the advantage of the transformer and extend its life somewhat, not to be worked continuously. I should like to have some light upon that matter.

MR. LIGHTHIPE: Beyond the magnetizing current a transformer takes, the more load it has up to its capacity the better, and it will run that much cooler and that much easier. There is no ageing in the transformer that amounts to anything, if made of proper iron, and it might just as well be worked at half the capacity or one-fourth the capacity, as to let it rest. You will get a better transformer by running it below its load, and keeping the heat down, although you lose the magnetizing current and lose the extra number of units. I don't see where the economy is coming in. I would run them all light, I think.

DR. VAN NORDEN: You think it is better to run all those transformers and run them light?

MR. LIGHTHIPE: I would prefer to run them light. It is like a battery of boilers. It does not save a steam boiler by letting it rest, and it is better to run the boiler light than to let it stand idle. You would get a better economy in fuel, and you will not save the boiler by letting it rest idle. I think it is pretty near the same thing with a transformer. It will age just as rapidly without the current running through it.

THE PRESIDENT: I would like to call on Mr. Eastwood for his experience in extending their lines and increasing their voltage. I am sure their experience will be quite interesting to the Association.

MR. EASTWOOD: Mr. President, it is a little awkward position to be put in to comply with your request to say something about something that has not been done. Of course we lay it all to the Spaniards, on account of not being able to get the transformers from the General Electric Company, because their works were appropriated by Uncle Sam, who had to fight Spaniards. So you will see we are directly interested in the Spanish war. I will say, however, that we have our pole line finished, and our line is all strung up in the air there, waiting for current at the high tension voltage.

THE HANFORD EXTENSION.

Our intention is this: We have a transmission of thirty-five miles from our power house to Fresno, and we extended our line directly to Hanford from our Fresno sub-station, a distance of thirty-three miles further, and to raise the voltage from the power house, starting with an initial voltage of 19,500 from the power house, and delivering it at a voltage of 17,000 at Fresno, and at about 16,000 volts at the Hanford end. Our intention is to put in a new set of lightning arresters for handling this high tension voltage, and the object of it all is, aside from raising the voltage, to increase the capacity of the main line from the power house to Fresno without adding any more copper. By raising the voltage we increase our line capacity very considerably, and do away with the necessity of any more investment for some time.

DR. VAN NORDEN: Do you change your insulators?

MR. EASTWOOD: We will change our insulators from the present porcelain to glass insulators. We have "Locke" glass insulators on the Hanford line throughout, and while we have not had a chance to try them yet, we feel satisfied that they are going to give us perfect success, for the reason that they have in other places.

MR. ENSIGN: How does the size of the glass insulators compare with that of the porcelain?

MR. EASTWOOD: Just about the same size as the porcelain that we are now using.

MR. LIGHTHIPE: You figure about three per cent. from Fresno to Hanford?

MR. EASTWOOD: Yes. We have a single circuit line built from Fresno to Hanford, and, having had the experience of building our former line, we have tried to build a line that, under the conditions which exist, would be almost a model one. We have increased the distance between our poles by setting them 150 feet apart instead of 120, as we had before. The Hanford extension is all on the level plains, and is nearly absolutely straight. We put in a single circuit, three wires, placing one of the wires on top of the pole on a pin driven into a hole bored into the pole, the pole being hooped on top. The other two wires are carried on a short arm, and the distance between the wires is thirty inches between the top wire and the side wires, and thirty-two inches the other way across. We have almost an equilateral triangle of thirty inches. We are using the Locke glass insulator with the porcelain base and iron pins. In making angles and turns, and where the strain would come on the top of the pole, so as to be likely to split out the pin, we have put on a short cross arm on the side of the top of the pole, bolting it fast, and placing the wire around two insulators that we put on this short cross arm, giving two pins to pull against instead of one on top. The line is head-guyed at all turns, and thoroughly braced in every way. We feel that we have a line that will give us very little trouble. We are now sending a 1000-volt current over the line for the purpose of running a four horse-power motor for running a printing press in Hanford. We hope to have the installation completed some time this fall, just as soon as our transformers arrive. After that we will probably have some further experiences to relate with reference to the matter.

DR. VAN NORDEN: Will he tell us what is the character of the transformer that he uses in the sub-station at Hanford?

MR. EASTWOOD: We will use the air-blast transformer at the sub-station at Hanford, and also the new ones we are putting in at the power-house and at the sub-station at Fresno; they are all General Electric transformers.

THE PRESIDENT: Perhaps Mr. De Sabla can give us some experience from their lines. Something over a year ago Mr. De Sabla made some remarks similar to those which Mr. Eastwood has made.

MR. DE SABLA: We have only five thousand volts in our transmission, but like Mr. Eastwood, we are thinking some, with our experience still ahead of us, of increasing our voltage to fifteen thousand or sixteen thousand volts, as our business is increasing. But in all our line transmission we have had no trouble. We have had quite a little experience in transformers, however; rather a sad experience to start in with, but our trouble is now being overcome by the use of air-blast transformers which are giving good satisfaction, and also oil and water-cooled transformers, which are giving no trouble whatever.

THE PRESIDENT: Has anyone had any experience with the water-cooling pipes in transformers becoming clogged?

MR. ENSIGN: We have some water-cooled oil transformers and they have given excellent satisfaction. We have had repeated short circuits, and, at one time had what appeared to be a malicious short circuiting of the line. The transformers had all the kinetic energy of three 250 k. w. machines with large armatures, and wheels weighing in the neighborhood of eleven thousand pounds, turning six hundred revolutions a minute, thrown into them time and time again. They have never failed, but always stood up to their work, and have given first class satisfaction—run cool and all that—but we have once or twice gotten some muddy water in them, and there has been trouble to pay for the while. They will heat up right away, because all these water-cooled transformers are built very light. The coil and the core iron for a 100 k. w. transformer are comparatively very light, and one of the advantages in making water-cooled transformers is that they can be made much cheaper and lighter. I found they had a similar experience in Niagara Falls, where the water appears to be impregnated with lime, and the water-cooling coils became clogged with scale as in a boiler. They had a secondary transformer built, hollow, with water through it, and they couldn't get one-quarter of the water through it in six months that they could at first. When you have not plenty of extra transformers, or where, sometimes, your load is such that you cannot take them apart and put in a new one—and it is a very ticklish thing to do—it is very annoying. We had to turn the fire hose into our transformer to wash it out.

MR. SINCLAIR: We have been operating 656 k. w. in water-cooled transformers on several systems about Redlands for about twenty months, and with the exception that Mr. Ensign states, we have had no trouble, though they have been running twenty-five per cent. overloaded all the time.

MR. LOW: At the last meeting of the Association, we listened with a great deal of interest to a discussion on a paper by Dr. Perrine, in regard to the difficulties attending the gathering of dust on the back of marble switchboards. The ideas then expressed by Mr. Lighthipe have been demonstrated to be correct by the experience at the Yuba power house, where it was found that the unpolished marble would not stand above 34,000 volts, but would break down, whereas the polished surface offered no difficulty. Is it not possible, in air-cooled transformers, that there will be a precipitation of dust which may give rise to eventual short circuiting? What means are at hand for cleaning out the dust that will be precipitated? Filtering the air is not done, and it seems imperative to do so, more especially when extremely high potentials are used.

DUST IN AIR-COOLED TRANSFORMERS

MR. LIGHTHIPE: I think Mr. Hutton's experience is due to dust in transformers. The high potentials enter through little wooden knobs and the dust collects there where it is very hard to reach. The dust collected along these knobs, and, after running several months, you would see little pin streaks, just as if somebody had taken a hot iron and made a mark across the wooden plugs. The short circuit Mr. Hutton speaks about, occurred from that one reason, and I think it occurrred before windows were in the power house, where heavy fog would probably collect on that dust, making a sort of mud, and the potential would creep across and cause the arc. We had to change the coils. It was entirely external; there was nothing the matter inside at all. I think the best cure for a transformer is to use a forty or fifty pound air blast; there is no other way. You can't dust them off, and I think all the modern transformer stations should be supplied with an air blast.

MR. LOW: Dust will certainly exercise an appreciable effect on transformers if it is allowed to get in, hence the advisability of filtering the air or hermetically sealing the transformer cases. I understand that at the Blue Lakes power house it has been found necessary to make a practice of cutting out a transformer at short intervals for the purpose of giving it a thorough cleaning. I have asked Mr. Doble to give some experience on that and perhaps he can do so.

MR. DOBLE: I understand that the transformers that have recently been put in over at the South Eureka Mine have given considerable trouble, and I think probably Mr. Lee knows in regard to that. You remember, Mr. Lee, that those were the old flat type transformer.

MR. LOW: Was it from dust?

MR. DOBLE: I am not sure.

MR. LEE: The South Eureka transformer was a twenty horse power motor transformer and failed from the fact that while a twenty horse power motor was put in, they were taking equivalent to about thirty horse power in current. While they did not exactly burn out, they got hot enough for it to start, and we substituted for those the oil-insulated transformers. I have not heard anything about the necessity of getting the dust out, but I think it is quite possible. The power house is in a very dusty location, but the necessity of taking them apart to clean them is more in the way of preventing trouble.

THE PRESIDENT: Are there any further questions in connection with the transformer?

MR. EASTWOOD: In the matter of dust I might state that last winter I put into our sub-station a receiver and air compressor, and in using it for the first time we found that we could blow out large cakes of dust that had accumulated in the transformers, in the armatures of the arc machines and in the motors that drive them, and we have found that, as an auxiliary to running a station where we have motors and transformers, an air compressor plant is a very valuable one. Very often we would have a hot terminal on one of our transformers, and the station man would turn an air hose on the terminal and cool it. In that way we have been able to carry a very big load, and probably we might otherwise have had a breakdown. It is absolutely impossible to keep the dust out of the transformer; in the air blast type the dust in the air will fall in and be lodged against the different parts as it goes up through the transformer and will cake there and accumulate. If you have any moisture come into your station, that will make mud.

MR. HUTTON: We have had an experience with dust on the back of high tension boards. The windows behind one of our high tension boards were left open, and, as the board had been set up for several months, some dust had accumulated on it. A fog came up that night and short circuited the back of the board. But in the case of a transformer and dust, it is an entirely different thing. On the back of a transmission board, all appliances are generally exposed, and the dust will make a clear track from one to the other. If moisture gets on the board you will have a leakage, while in transformers they are wound and covered with mica, so there is no

chance for the dust to get on the wire itself at all. It appears to me that wherever you have anything in the shape of a conductor, where they are exposed to high potentials and dust happens on them, there is much more liability to have trouble there from dust than where it is covered up. I think it is a good thing to keep dust off, but I don't believe there is any particular trouble from dust in transformers, at least I have never seen anything of the kind during an experience of about three years. We use a little bellows and an ordinary duster to keep the transformers clean, and have never had any trouble from dust.

THE PRESIDENT: Have we any further experience to draw on in this connection? As I understand this discussion, and the experiences given here, the evidence is rather in favor of the oil,- water-cooled transformer. If I am wrong I beg to be corrected. As that was, to a certain extent contrary to Mr. Lighthipe's first remarks, perhaps it would be in order for him to show how far that comparison should be drawn, or that conclusion reached.

MR. LIGHTHIPE: I merely quote our company's experience. We have tried both, and have adopted the air blast as being preferable to the oil, in first cost, because it has been proven that we can build the oil, water-cooled, transformer cheaper than the air transformer, but we have decided that an air blast is preferable, and we are running the voltage up on the air type. Better results were obtained from air than oil, and cheapness does not cut any figure.

MR. HUTTON: I can say one thing in favor of the air-cooled transformer. We put in three forty k. w. transformers, located halfway between Sacramento and Folsom. They operate a two thousand volt motor, and after we had started up, the belt began to slip, and ran off on one side, and jammed in between the brick wall and the pulley. In consequence, the motor began to slow down and the belt began to smoke, and the party in charge pulled out the switch, and there being an enormous current flowing, it arced across and made a short circuit. We had put in copper fuse on the transformer lines, which held quite a while before blowing out, but the load was enough to slow down two 750 k. w. generators.

INSTANCES OF TRANSFORMER OVERLOADING.

THE PRESIDENT: Are those oil transformers?

MR. HUTTON: No, air; natural draft.

MR. ENSIGN: I had a similar experience represented in a load of 120 horse power at the Redlands power house. At the pumping house where there was something wrong with a centrifugal pump at the bottom of the shaft, forty feet beam. They were trying to force power enough into the pump to get the water down so that they could find out what the trouble was. We got there just as they finally got the water down, after having been pumped for five hours. The whole pump was hot and burst into smoke. The fluctuations at the power house showed that they were absorbing 120 h. p. delivered at the power house, and there was another motor running on the same transformer taking twenty-five h. p. There was 145 h. p. and the transformer never warmed up to any appreciable extent. They found the pump full of wedges that had been used in tunneling.

The Convention then adjourned until 8 p. m.

EVENING SESSION.

The evening session convened in the assembly room shortly after dinner, with Mr. H. H. Sinclair in the chair, in the absence of the president, Mr. W. Frank Pierce, and of the vice-president, Mr. C. N. Beal.

THE CHAIR: We will now listen to a paper by Mr. John Richards, on "Centrifugal Pumps," to be read by Mr. Doble:

MR. DOBLE: I might say for the information of those not present at the last meeting, that as the subject of "Centrifugal Pumps" had been brought up as a very important one in connection with electric transmission, we invited Mr. John Richards, who, as most of you know, is well versed in matters relating to centrifugal pumps, to prepare a paper. He was unable to do so at that time, but he sent a memorandum which I will read, because he refers to it in this present paper. That communication is as follows:

The writer had the honor of an invitation to attend the February meeting of your Association in this city, and to contribute a paper or essay on the subject of adapting centrifugal pumps to be driven by electrical motors. Previous engagements prevented doing more at that time than to send in a brief memorandum relating to the subject. No copy of this paper was preserved, but as remembered it included a promise to at some future time present the matter in a more complete form. This I will now attempt to do in a compendious way with some illustrations of practice that will, no doubt, be of interest to the members.

The paper referred to in the communication just read was presented to the February meeting, but as it is brief, I will again read it. It is as follows:

I venture to contribute the following on the topic named in your note, which can, if you choose, be entered on your minutes.

The common opinion that centrifugal pumps require adaptation to a constant head is an error, except as to an inconsiderable loss in efficiency. This opinion arises out of its corrollary, namely: that centrifugal pumps have to operate at a constant, or nearly constant, velocity, which is true within narrow limits, being variable only in a slight degree by constructive features, such as the form of vanes.

These things being assumed, I need not say that centrifugal pumps lend themselves, with fair adaptation, to electrically transmitted power, under variable heads.

This matter will be made more clear from the following table which I employ in preparing designs for such pumps. It is not exact, but is near enough for practical working.

Head to produce the flow.	Flow in feet per minute.	Discharge in gallons per inch of area.
0.5	240	12
0.6	300	15
.75	360	20
1.0	480	25
2.0	600	31
2.5	720	37
4.0	900	46
7.0	1200	62

From the above table, it may be seen that a pump running at a constant number of revolutions, may operate at any head, and that variation of head produces corresponding change in flow and volume as in the second and third columns.

In respect to efficiency, this would, if discussed, involve certain intricate conditions, such as friction of the water, considered not only in respect to pipes and pump ducts, but also as the degrees of arc through which the water passes while in revolution. The losses by variation of head will therefore be, as you will perceive, not serious under a constant rate of revolution and variable heads.

Mr. Doble reads Mr. Richards' paper appearing on page 8.

THE PRESIDENT: As this is a matter which is bound to be of great importance, for the pumping of water in the southern portion of the State for irrigation, and in the northern part of the State for other purposes, is a duty for electric motors that will increase very rapidly, it is a field which I find that we of the southern part of the State are very anxious to exploit properly, hence I would like to ask a very full discussion of this matter.

MR. LIGHTHIPE: A great proportion of the power of the Bakersfield plant is operating centrifugal pumps for irrigation purposes and I am disappointed that Mr. Beal is not here, because the Bakersfield plant has gone more fully into this matter than any other plant. The Sacramento company is branching out in this direction and we recently installed

something like a 150 h. p. irrigation plant outside of Sacramento. But, as Mr. Richards says, the operation of centrifugal pumps by electric power constitutes an ideal plant. It gives a rotating motion that operates a rotating blade in a centrifugal pump and the two fit together very compactly. I think there is a great field of development in this line.

PUMPING BY ELECTRICAL POWER.

MR. HUTTON: We have a plant that has been pumping sewerage for the city of Sacramento for the past year, and it has given no trouble. The last one we put in is used for irrigation purposes. It is a centrifugal pump, and the only trouble we have met so far has been an insignificant one with the pulley; otherwise it is giving good results. The gentleman who owns it, Mr. Stevens, seems to think that the matter of pumping is going to be quite an object with the farmers along the line there, between Sacramento and Folsom. The district there is very sandy, and in the dry season it does not hold the water very well, and irrigation is going to be a good thing. So I presume that if the experience with this present installation is satisfactory, which undoubtedly it will be from present indications, there will be quite a field for centrifugal pumps on our line. I think this one in particular is going to come out all right and work well.

MR. GILBERT: In connection with the pump that Mr. Richards speaks of, his practical point, I think, is that the speed of the pump can be proportioned directly to that of the motor, securing a direct connection, which is one of the difficulties we have met. If Mr. Richards has contrived a pump that can be directly connected, I think he has made an important advance.

MR. LIGHTHIPE: Another important point about pumping is that it is a great thing to help out the load factor. Almost every consumer who pumps water for irrigation is willing to take electric power at a time when the lighting or other heavy load is not on. The time when water goes on to an orchard makes very little difference, and they can as well irrigate during the small hours of the morning, or when the load is very light. This will improve our load factor considerably.

THE CHAIR: In regard to the load factor, the Redlands Company has about 120 to 150 h. p. in pumping motors, and all are connected on the basis Mr. Lightpipe suggests; that is, our contracts are made reserving the right to the company to cut off the supply of power to them between the hours of 6 and 10 in the summer time, or 5 and 9, as we may desire, according to the season of the year, and it has been working very satisfactorily indeed for something over a year. A pumping load of this nature is taken on at a time insuring the greatest profit to a water power plant. We have had some experience, mostly in small units, which has extended over some little time and been considerably varied, and I would like to call on Mr. Ensign to give such information as he has on this matter.

MR. ENSIGN: We are operating a branch 10,000-volt line, seven miles long, extending northwest from Colton to three and a half miles northwest from San Bernardino, on which are three sets of two 20 k. w. natural draft transformers connected, each set furnishing current to two 20 h. p. induction motors, except one which has also one 10 h. p. motor, all driving centrifugal pumps. Centrifugal pumps lend themselves very readily to motor driving, and yet when using induction motors, which necessarily give a fixed speed, annoying difficulties sometimes arise. In the locality referred to, the source of water was originally flowing wells, until they began to pump them to increase the flow, when they all had to pump, and every pump added lowered the water, so the others found it necessary to speed up their pumps a little, or lower them deeper into the wells. Then if some pumps shut down, the water would raise and overload the other motors. So these people either keep on hand a supply of different pulleys to meet the varying demands on the pump, or mount the pump on a vertical movable carriage.

Each design of centrifugal pump will lift and force a certain distance at its highest efficiency at a certain speed. A change in any one of these conditions effects the efficiency. We have on that branch line a pump with a vertical shaft, which is the one that absorbed 100 h. p., due to wedges and other rubbish getting into it during the construction of the well. This pump is mounted on a vertical carriage, and more shafting is put on as the pump is lowered; but if the water carries much grit, whenever the pump shuts down the water rising in the well will be liable to ruin the bearings, as has been the experience with this pump. I am not myself in favor of centrifugal pumps in such a place with varying head of water, if I can find some other way of doing the work, but there are very many places where centrifugal pumps are undoubtedly the best. On the whole, this branch line has given a satisfactory water supply, and has given a good twenty-hour load for the power company.

There have also been two compressed air lifts installed on our system, which get more water from the well, but perhaps take a little more power for the same amount of water lifted; but on the other hand, they have less shut downs and repairs than the centrifugal pump. The air-lift consists of a compressor driven by motor with what appears to be a simple air pipe run down in the well, which, with its discharge pipe, can be raised or lowered to suit the height of the water. It is the most satisfactory method I have yet seen for raising water, though it is a very hard thing to get an accurate measurement of power on account of the fluctuations caused by the reciprocating motion. We have a large number of pumps connected to our system, and many more in prospect. A number are deep-well pumps; in one the pump cylinder is six feet long by nine inches in diameter and raises the water 120 feet, delivering about twenty miner's inches at an expenditure of 8 h. p.

MR. EASTWOOD: Last winter we put in a small pump for the county orphanage, which consisted of a 3 h. p. motor, directly connected on the same plate with an inch and a half Crow centrifugal pump, and which is connected up with large section and two large discharges, one of which goes into a tank and the other is for an irrigation discharge lift about eight feet above the pump. The great difficulty in cases of this kind is to get a pump that will run at the speed of the motor. The 3 h. p. motor runs at a speed of 1,800, and to get a pump small enough to not overload the motor was quite a problem. In the construction of this pump the veins were extended, and separated by a very small notch from the next vein beyond, so allowing but a very small quantity of water to pass through the pump. With a lift of about sixty feet from a well that supplied an abundance of water, we had difficulty in keeping the motor from being overloaded. It took about 5 h. p. to work the pump as it was, so I put a check valve in the suction and cut the suction down, and in that way it gives excellent satisfaction. In addition, the Fresno Water Company is putting in a 50 h. p. centrifugal pump for use as a secondary pumping station. There we have a six-inch compound centrifugal pump which will be driven by a 50 h. p. induction motor belted. The lift is 110 feet, and the pump is arranged so that part of the lift is taken care of by one of the pumps, and another pump like it takes care of the other lift. I think this method has been well tried and has proved very satisfactory. I may add that for a couple of years we have been furnishing the city of Fresno with water pumped by an electric motor. We are running a triple-plunger pump having a capacity of four million gallons in twenty-four hours, with a 75 h. p. induction motor, belted and geared. It has given excellent satisfaction.

MR. LIGHTHIPE: Regarding deep plunger pumps, our experience shows that they throw a severe strain on the motor.

It is all load pulling up, and worse than no load going down. It is not noticed on a large plant, but on a small plant it dips the lights at every stroke. In the ice works at San Francisco we installed a plant in which most of the load was the motor to run a deep plunger pump. They wired in a few dozen lamps, but the volts were so irregular that the lamps could not be used at all. Being direct current, the easiest way around the trouble was to put a heavy series winding on the motor to make it accumulative, so that when a heavy load came on the motor slowed down. By putting in a good deal of wire on that series we equalized the voltage so one could scarcely see a wink on the lights.

MR. ENSIGN: I think compressed air is better in deep wells. But when a motor drives a compressor there will be trouble with the current in a small plant, as even a small compressor will make a fluctuating on the lights part of the time. We had a breakdown in one of the cylinders of our big compound pump, and if all three plungers were running there were six points at which this pump was working. If you take out a few points, you get a gap, and the lights will be bobbing up and down all over town on account of the variation in the amount of current used. The needle in the ammeter will be bobbing back and forth, and you will have the same thing all over the system. The air-compressor will do the same thing exactly, as it gives an oscillating motion. We ought to apply a constant power, and I don't how it can be done any better than with a centrifugal pump.

THE CHAIR: As the operation of that pump caused a flickering in the lights, I would like to ask what proportion the pump bears to the total load?

MR. ENSIGN: It is a very small proportion, because it only takes 60 h. p. to run it. It makes fluctuation and perceptible flickering.

MR. LIGHTHIPE: I think the point to aim at in any mechanical device operated by electric motors is to get a rotary motion,—to avoid the reciprocating motion as far as possible in every case, even on air compressors. It is not the work that the plunger does so much as it is this large column of water that has to be accelerated. It is acceleration that cuts the figure, and we should encourage the improvement of the rotary pump, or anything rotary that goes on electric work. We want to get rid of the reciprocating motions, if possible, and the more steady tongue we have on motors the more steady the load will be, and the more encouragement we can give to the improvement of centrifugal pumps the better we are off in the service we can give.

THE CHAIR: While that would seem on its face to be so, yet our experience does not seem, necessarily, to bear that out. We have an ice plant operating at Redlands, and Mr. Ensign can tell you the effect of that double-cylinder compressor, when only one side is running, and when the load on that is a very large proportion of the actual load.

(Proceedings of the evening session of the Pacific Coast Electric Transmission Association will be concluded in the August number of THE JOURNAL OF ELECTRICITY.)

TO PREVENT LINE LEAKAGE.

ON June 7th letters patent were granted to Fred M. Locke, of Victor, N. Y., on an improved high tension insulator, by the design of which it is proposed to prevent leakage of the current from the wire over the insulator to the supporting pin, thereby obviating the burning off of the pin. This Mr. Locke accomplishes by so elongating the inner petticoat of the insulator that it will closely cover or enclose the supporting pin down to a point adjacent to the cross arm, and in addition this inner elongated petticoat is made smaller in diameter in proportion to the petticoats of the insulator above it.

The burning off of pins where high voltage currents are transmitted has rendered necessary some means of preventing this leakage, and Mr. Locke claims that this can be accomplished by the extension of the inner petticoat in the manner described, thus providing a protecting sleeve for the pin and increasing the arcing distance of the current around the insulator.

Mr. Locke desires the announcement made that parties buying such insulators from the R. Thomas Sons Company will be asked to pay royalties on the same.

Fraternal

THE PACIFIC COAST GAS ASSOCIATION.

Mr. John A. Britton, secretary of the Pacific Coast Gas Association, has issued the following official notice of the coming annual meeting of the Association, to be held in San Francisco during the present month:

The sixth annual convention of the Pacific Coast Gas Association, Mr. F. H. Eichbaum, President, will be held in San Francisco, on Tuesday and Wednesday, July 19 and 20, 1898, in the office of the building of the San Francisco Gas and Electric Company; morning sessions, from 10:15 to 12:30; afternoon sessions, 2 to 4:30. The Board of Directors will meet on Monday, July 18, at 8 p. m., at headquarters, which are hereby established at the office of Mr. E. C. Jones, chief engineer of the San Francisco Gas and Electric Company, No. 415 Post street.

Copies of all papers, questions, and applications for membership, must be mailed to the secretary prior to July 18. Members to whom questions are assigned are requested to send answers promptly.

Papers will be submitted by the following members on subjects to be announced: E. C. Jones, C. O. Poole, John L. Howard and F. Foveaux, of San Francisco; O. M. Gregory, San Jose, Cal.; John A. Britton, Oakland, Cal.; W. M. Parker, Bellingham Bay, Wash.; A. Gutsch, Fresno, Cal. In addition to his address as president, Mr. Eichbaum will continue his "Reminiscences." Mr. George H. Hollidge of Merced, Cal. has charge of "Wrinkles," and Mr. John Clement of Red Bluff, Cal., is directing the "Experiences." It is hoped that the members will contribute liberally to both these departments.

An excursion is arranged for Thursday, July 21, particulars of which will be hereafter announced.

The Secretary has on hand a number of bound copies of the "Proceedings," which are purchasable at $2.00 per copy.

MR. E. H. FORST has been appointed manager of the consolidated interests of the Pacific Coast Electric Company and the California Electrical Supply and Construction Company, now known under the name of the former concern and located at 1145 Market street, San Francisco.

MR. M. I. SIPE, late a foreman of the San Francisco office of the General Electric Company, has been made Superintendent of Construction for the Washington Water Power Company of Spokane, Wash.

PROF. C. L. CORY, of the Department of Electrical Engineering, University of California, is spending the summer vacation in making a tour of the principal electrical plants in the Pacific Northwest.

MR. E. C. SHARP, late of Los Angeles, has been appointed manager of sales for the Pacific Arc Lamp Company of San Francisco, which will hereafter occupy his entire attention.

MR. IRA G. FRANCIS, City Electrician of Los Angeles, was in San Francisco last week.

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EDITORIAL.

EFFICIENCIES, ACTUAL AND THEORETICAL.

The vaunted accuracy of scientific, or rather engineering determinations is delusive in many problems wherein exact results as to efficiencies are to be predetermined. Witness, for instance, the earnestness and unity of purpose with which the greatest governments of the world are endeavoring to design ships of war that will attain the highest possible speed under prescribed conditions. What is the "highest possible speed?" No one knows. The very best of engineering skill is engaged; every facility that money can buy or human ingenuity can devise is afforded without stint to aid in securing perfection in model and design; the experience and wisdom of the world's greatest shipbuilders add refinements to the work of the designers, and yet, who of all these can definitely announce the speed of the ship prior to the momentous day of her trial trip. A vessel may be designed for a given speed which, under proper conditions as to steaming, engines, model and bottom, may be made or even exceeded, but the speed which it is designed to make and the speed which it will actually make will not, it is safe to say, be identical. The one is theoretical, the other practical; and theory and practice are seldom, if ever, in entire consonance.

Though the instance cited is an extreme case, because of the many attendant conditions which exert important influences in the final result, it is by no means without parallel in engineering work. Equally impossible is it to determine beforehand the electrostatic capacity of a long distance, high voltage transmission line because of the varying influences of the power factor, atmospheric conditions and line separation; or to accurately estimate the over-all efficiency of a transmission plant because of undeterminable factors, among which are the co-efficient of friction of the pipe line and the changes in efficiency in water wheels, generators, transformers and line with each change in load; or, more simple yet, apparently, to accurately determine the mechanical horse-power that will be derived from a stream of water of given size and head, is impossible until the actual trial is made.

It is a consideration of such matters as these that brings out most strongly the differences which invariably exist between the theoretical and the practical—and practical is but another word for "real" and "effective." A mountain stream may be torrential during certain seasons, during which its energy may be reckoned with entire propriety in thousands of horse-power, but at the end of the summer the stream may be but a rivulet incapable of doing work of any commercial utility as a source of water power. This would reduce the effective value of the water right to practically *nil*, for, as a chain is no stronger than its weakest link, a water power ordinarily finds its limit of commercial availability in its minimum flow. Conservation will secure an equalization of the minimum and maximum flow, thereby increasing the value of the water power, but introducing counter issues such as seepage and evaporation, which still further render it impossible to determine before the works are installed and tested, just what the exact plant efficiency will finally be. Moreover, no two tests of a plant, whether of an electric or hydraulic nature, will show exactly uniform results and a failure to properly appreciate the many uncertain and indeterminate factors entering into considerations involving difference between theoretical and effective results, may be ascribed as a cause of the major portion of the misfortunes that have overtaken enterprises which have, sooner or later, been reduced to unsatisfactory, unprofitable and chaotic conditions.

EUROPEAN INDUSTRIAL CONDITIONS.

The industrial situation in Europe is a theme that, prior to the outbreak of the Hispano-American war, was productive of much discussion in both the lay and technical press, but the exigencies of war have so crowded the columns of the press that the American public is overlooking the unfavorable conditions of trade which the vigorous protective policy of the present administration is heaping upon European countries to the almost incalculable benefit of our own industries. The seriousness of this situation is strongly set forth in the accompanying letter received from Professor A. Van der Naillen, President of the Van der Naillen School of Engineering of San Francisco, who indicates, as well, some of the advantages that are bound to accrue to American engineering interests from a continuation of the present national policy. Professor Van der Naillen is so well and favorably known that his letter cannot but be accepted as a truthful exposition of the existing European situation, as well as a sage forecast of the probable influences which it will exert on American engineering trades.

Writing from Liege, Belgium, under date of June 19th Professor Van der Naillen says:

> You have no idea what engineering opportunities are going to arise for those of the coming generation who will study and make themselves proficient in their chosen professions. These European countries are being steadfastly ruined by the protective policy of

President McKinley. The industries here are not paying dividends, while many manufacturers are running at a loss and all have an eye turned toward America, whither they hope to take their entire industrial plants or close up their factories here and invest their capital in the United States. Moreover. I have recently witnessed the elections here and the Socialists and Anarchists have made great gains. Many incipient revolutions have had to be suppressed and the industries feel nervous and capital unsafe. Worse than this, the universal revolution is feared in the not-far distant future, so that all eyes are turned toward America as the the only country worth while to live in and the only country offering to capital, intelligently invested, many chances of development and increase, and then the services of engineers, electricians, mechanics, draughtsmen, surveyors, assayers and all similar professions, will be more and more in demand. The mining engineers of Europe confine their studies mostly to coal and iron mining and possess but a skimming of knowledge of the precious metals, so that the skill of the California mining engineer will at least always be required. The science of electricity, too, is bound to be of more importance than ever, and I am just commencing a thorough investigation of the school of electrical engineering established here in Liege and founded by Montefiore Levy. It is really the only school teaching the electrical science exclusively, and it is reported to be the best and most complete in theoretical instruction, but for the practical application of these theories, the credit is given to America. We shall soon see how long America has only this credit.

PETROLEUM IN SOUTHERN CALIFORNIA.

According to the State Mining Bureau the production of petroleum in Southern California for 1897 amounted to nearly 2,000,000 barrels, of which 1,339,011 barrels were produced in Los Angeles county, 368,228 barrels in Ventura county, 130,136 barrels in Santa Barbara county, about 70,000 barrels in Fresno county, and about 50,000 barrels in Santa Clara county. This shows an increase of about 750,000 barrels over the production for 1896, but nevertheless the wells in the Eastern field within Los Angeles are beginning to fall off in production and oil men are looking around for new fields to conquer.

It has now been so long since oil was "struck" in Southern California that if it were going to be found in sufficient quantities to bring about cheap fuel, its influences in this direction would certainly have been appreciated long ago. It is reported that the greater portion of the oil produced in and about Los Angeles is used in the locomotives of the Santa Fe system on that division. At all events, there is no longer a doubt but that electrical transmission interests in California have nothing to fear from the era of cheap fuel that, it was said, would result from the oil of the Los Angeles fields.

A NEW DRESS.

THE fact is self-evident that the beginning of Volume VI of THE JOURNAL OF ELECTRICITY is marked by several departures from the typographical style which has been characteristic of it almost since the dawn of its existence. The general proportions remain the same, but among the typographical changes will be noted a little more display, and the appearance of a greater amount of reading matter because of the extended use of smaller type. It is believed that these changes are for the better—but of this let critics speak.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

COST OF PRODUCING ELECTRICITY.

Mr. Robert Hammond recently contributed a paper to the British Institution of Electrical Engineers upon the cost of generating and distributing electrical energy, taking as a basis of his computations the yearly statements filed by the electricity supply works under the electric lighting act of 1882. Naturally a wide diversity of results is given, but the returns expressing most closely the existing conditions show that the total cost per kilowatt-hour ranges from 1.13d. to 6.04d, while nine of the leading electricity works produced electricity for less than 2d. per kilowatt-hour during 1896-97. The paper, moreover, sets forth that the conditions which make these low costs possible are due to: (1). Heavy output, as is shown by diagrams proving that the costs fall rapidly as the output increases; (2), Load factor, or the ratio of the actual units generated to the product of the maximum of the year and the total hours of the year; (3) A thoroughly reliable generating and distributing plant, adequately tested; (4) The "engineer factor," as is brought out from the fact that in every one of the plants where low costs prevail, the engineer in charge is distinguished for his competence and assiduity, and (5) all-round efficiency in the generating and distributing plant.

The paper, which is illustrated with diagrams based on data secured as stated, is in reality a succinct embodiment of the performance of English central stations in the matter of the cost of producing electrical energy therefrom and the suggestions it contains are worthy of most mature consideration.

A NOTEWORTHY AND STRIKING ARTICLE.

The *San Francisco Call* gives the following editorial notice concerning the Yuba-Marysville transmission described in the May issue:

The current number of THE JOURNAL OF ELECTRICITY gives the place of honor in its pages to an elaborate description, richly illustrated, of the electric power transmission system recently established by the Yuba Power Company at Marysville. The article is a noteworthy one, and presents in a striking way one of the most important of the accomplishments of Californian enterprise.

It is noted that just 125 days elapsed from the date when the power company began work on the system until it was placed in operation. The work achieved during that comparatively short time included the entire rebuilding of thirty odd miles of water system, the location of the power-house, the erection of the pole line with two sub-stations, the city distribution of over 5000 lights, and the installation of all the hydraulic and electrical equipments of the plant. With this record the company holds the well merited distinction of having made the quickest installation of that magnitude ever accomplished.

The plant, moreover, is as notable for its excellence as for the speed with which it was built. Rapidly as the work was performed, thoroughness and quality were never subordinated for the sake of gaining time. The system stands, therefore, as one of the best illustrations in the world of what American science and engineering skill can do in the way of providing for the transmission of electrical energy.

The example set in this case, will, of course, be followed elsewhere. The topography of California is well adapted for such enterprises, and the date can hardly be far distant when

nearly every city of note in the State will have power furnished it on lines similar to that which is now proving such a benefit to Marysville.

ELECTIC PROPERTIES OF GLASS.

Now that glass insulators are rapidly coming into popularity for the support of transmission lines, any information concerning the electric properties of glass is of value. Messrs. Andrew Gray and J. J. Dobbie have given to the Royal Society a report of the first installment of work undertaken with a view to finally determining, if possible, the circumstances which affect the conductivity and specific inductive capacity of glass, from which it appears that potash and soda lime glasses have a higher conductivity than flint glass. The electric conductivity of glass falls off almost regularly as the amount of lead oxide increases, while it rises with the amount of soda, and the glass which possessed the highest specific resistance—$8,400 \times 10^{10}$ ohms—contained 40.5 per cent. of lead oxide, 7.5 per cent. of potassium oxide, and 2.1 per cent. of sodium oxide. Both of the lead glasses dealt with contained a still higher percentage of lead oxide and were almost free from soda, and the electrical resistance was so great as not to be measureable. It is impossible to say how far this result is due to the increase of lead oxide, and how far to the elimination of soda—a point which can only be decided by preparing a lead glass in which the potash is replaced as nearly as possible by the equivalent amount of soda. It is noteworthy that a glass whose chemical composition may be expressed by a simple chemical formula invariably has a high resistance.

ELECTRIC MOTORS IN THE STABLE.

THE electric motor has become a necessary adjunct to every well appointed modern stable, whether livery or private, and horses are now groomed and clipped by electricity, with neatness and dispatch.

The advantages of the application of the electric motor to

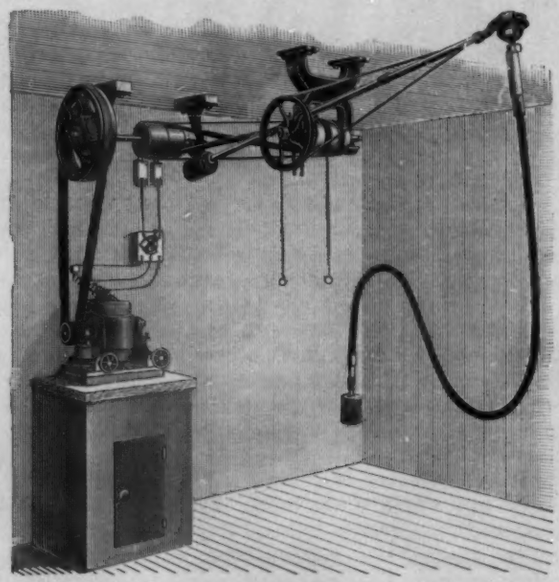


FIG. 1—OLD METHOD OF DRIVE THROUGH DOUBLE COUNTERSHAFING.

grooming and clipping machines, were early realized by an eastern shearer company and its efforts toward supplying a demand for electrically driven groomers and clippers has met with considerable success. Hitherto, however, it has supplied merely the machinery exclusive of the motor, but owing to a demand which has arisen for complete grooming and clipping installations, it is now supplying the motor as well. In doing this, however, it has found it necessary to simplify in a large measure the driving mechanism.

The first of the accompanying illustrations shows a grooming and clipping machine driven by a bipolar motor through double countershafting with conical and idle pulleys. This method, while it allows of the operation of two or more groomers and clippers from one motor, was not satisfactory on account of the complication of belts and pulleys necessary, and when it became a question of furnishing both operating and driving machinery, it was felt that some more direct method of drive was needed. This was found in the small power, moderate speed motors developed by the General Electric Company, which in addition to its line of small power induction motors has also recently perfected a line of direct current small power motors known as the "C. A." type. These motors may be run in any position either attached to the wall, set on a bracket or hung from the ceiling, and have been found peculiarly adapted to drive groomers and clippers.

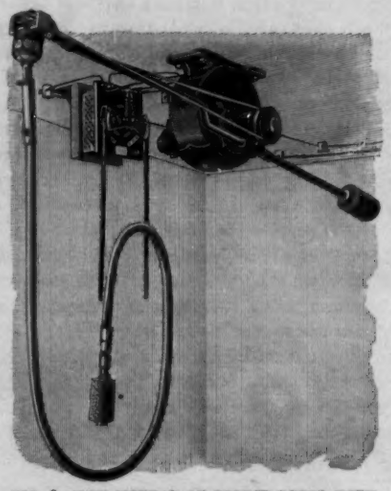


FIG. 2—NEW METHOD OF DIRECT DRIVE WITH "C. A." MOTOR.

The second illustration shows a more recent machine complete with a one h. p. "C. A." motor and automatic starting rheostat. In this case no floor space is occupied by the motor, the counter-shafting is eliminated, and the belting is reduced to a single belt from the motor pulley to the pulley attached to the flexible shaft of the groomer and clipper. The motor is fastened to the ceiling beams in an inverted position and the counterpoise, or balance arm, is attached to a swivel on the motor case. The automatic starting box, also fastened to the ceiling, is of the reversing type, with the contact arms pulled in either direction by leather straps. This clipping and grooming outfit is singularly compact and simple and requires almost no attention beyond an occasional oiling. In ordering, it is simply necessary to state the nature and voltage of the current, and, if alternating, the phase and number of alternations.

With the electric motor-driven groomer and clipper, a horse may be thoroughly brushed in about two and a-half minutes and clipped in about thirty-five minutes.

Electro-Therapeuty

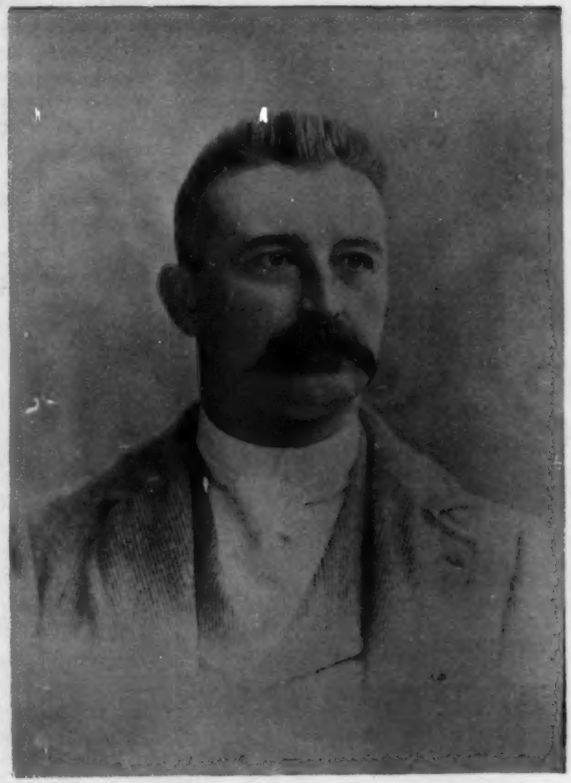
ANAESTHESIA ELECTRICALLY INDUCED.

While making experiments on the sensations derived from sinusoidal currents, it was recently discovered by Prof. Scripture, of Yale, that anæsthesia of the tissues resulted from currents of high frequency, the condition even persisting for some time after the removal of the electrodes. This should excite the attention of medical men, surgeons more especially; and if such local anæsthesia proves to be wholly practicable and safe, it will prove a veritable boon.—Scientific American.

Personal

MR. JAMES ALFRED LIGHTHIPE, an excellent likeness of whom appears on this page, holds the enviable distinction of being universally more popular and esteemed than any other electrical engineer on the Pacific Coast. He is, above all others, the one man in the profession who can rest secure in the knowledge that despite his very active service in electro-technical matters, he has administered his high offices so fairly, so honestly, so impartially and so competently that he is respected, admired and even beloved by all.

The best engineers, like true poets, are born, not made, and as the professional rating of Mr. Lighthipe is of the best, his engineering career forms no exception to the general rule. So it transpired that while quite a young man, Mr. Lighthipe found student life less congenial than active work and accordingly he left the Stevens Institute of Technology, at Hoboken, N. J., before finishing his course and became an assistant of Mr. T. A. Edison at the little laboratory at Menlo—the institution that will always stand in electrical history as the birthplace of Edison's greatest inventions. About this time, 1879, the phonograph, the Edison telephone, and the host of other Edisonian inventions, were under development or being introduced. In those pioneering days, men of some experience, of sound judgment and, more than all, of great intellectual resources, were in demand, and Mr. Lighthipe was chosen as one of the corps to go to London where, under the active management of Mr. E. H. Johnson, they "set up" the first "chalk telephone" installation in a foreign country. The brief period that Mr. Lighthipe spent with Edison at Menlo Park was during the hard working period before fame and fortune had favored the great inventor. The period was one of never ending interest, hence a single anecdote may be permitted:



JAMES ALFRED LIGHTHIPE.

In a portion of the laboratory away from all work-a-day (and-night) devices was a small pipe organ that occasionally gave solace to Edison. When distraught with a brain-racking problem and after long hours of labor, he would sit himself at that organ and play and sing in quest of relaxation. But in play, as in work, the enormous energy of the man was beyond comparison. He would play and sing, as the vernacular of to-day goes, "to beat the band," until, unmindful of the rate at which his feet were pumping, a wheeze and rapid dying out of the chords would tell that he had burst the bellows again. Then he would say: "Lighthipe, better patch it up again so I can finish my tune," which Lighthipe did, and so often repeated that the bellows became a prominent specimen of the none-such family from the sheep skin patchings on it.

It was in the summer of 1880 that Mr. Lighthipe was sent from London to Antwerp where, under the late Mr. Gardiner G. Hubbard, he was installing engineer for the International Bell Telephone Co. The two years following were spent in supervising the erection of the telephone exchange system of Antwerp and Verviers, Belgium, both using Blake transmitters and Bell receivers. At the completion of this work Mr. Lighthipe returned to London where he remained for six months as superintendent of the British Insulite Company. The rapidly growing importance of the Edison system, including dynamos, incandescent lamps and all accessory equipments, made it advisable to start factories for their manufacture on a large scale in the principal continental capitals, and accordingly Mr. Lighthipe was sent to Paris where, under the management of Mr. Chas. Batchelor, he entered the factories of the Societe Industrial and Commercial d'Edison, at Ivry. Nikola Tesla was also at the same factory at Ivry, prior to his coming to America. After about one year's service in Paris, Mr. Lighthipe was transferred to Berlin, where he held a similar position with the Deutsche Edison Gesellschaft. A year later he returned to New York where he remained as engineer for the Brush-Swan Company for nine months, after which he started in business for himself in Philadelphia, Pa. Twelve months in commercial life convinced Mr. Lighthipe that engineering proper was more suited to his taste than mercantile pursuits and so he returned to active electrical work at Wilmington, Del., as chief electrician of the Wilmington City Electric Company. Mr. W. S. Heger, now manager of the Pacific Coast office of the Westinghouse Electric and Manufacturing Co., was then Edison agent for Delaware, Maryland, Virginia and North Carolina. When Mr. Heger resigned that position to take the Pacific Coast office of the United Edison Manufacturing Company, Mr. Lighthipe accompanied him, arriving in San Francisco on January, 1, 1890, and was at once made superintendent of construction. When the various Edison interests were reorganized into one concern—the Edison General Electric Company—Mr. Lighthipe was retained as District Engineer for the Pacific Coast, and later, when the Edison General Electric Company consolidated with the Thomson-Houston Electric Company as the General Electric Company, Mr. Lighthipe was advanced to his present position of Chief Engineer for the Pacific Coast district at San Francisco. Mr. Lighthipe's absolute honesty of opinion and purpose, and this trait, perhaps more than any other, has won for him the deserved popularity of which he might so well be proud.

Mining

ELECTRICITY IN MINING.—III.

LIGHTING OF MINES.

Science had made a great step when Sir Humphrey Davy called to his assistant to come and see the effect of a gauze shield on an adjacent flame, and from that phenomenon developed his safety lamp; but science has made a long step in advance of even that day in the evolution of modern methods for facilitating the work of mining.

Among these advances, none has been more striking than that of mine illumination. The question is again one of economy, modified by considerations of safety. The problem of electric lighting is one that is of some complexity, yet without any uncertain factors. From the coal pile to the incandescent filament in the vacuum bulb, through boiler and engine, dynamo, line, transformer, house wires, and finally into the glowing source of light, is a long series of transformations. With the average apparatus of this kind, the proportion of actual energy in the coal that is utilized in light,

BELTED ELECTRIC FAN FOR MINES.

is only about one-sixth of one per cent., yet nature is so rich that she overlooks the waste and gives ample return to the human race even under such conditions.

Where a source of water power is available for lighting purposes, the efficiency of a lighting system is increased in a truly marvelous degree. The two most efficient, practical machines known to engineering science, are, without doubt, the electric dynamo and the turbine water wheel. The efficiency of the former runs above 95 per cent.; that of the latter has been found to be as high as 97 per cent., and in practice is probably above 93 per cent. Assuming the values 95 per cent. and 93 per cent. for the respective efficiencies, the comparative economy of the steam driven and water plants may be readily shown, as follows:

The ordinary standard of economy is the "watt-hours per pound of coal." Assume the heating value of a pound of good coal to be 12,000 thermal units, which is equivalent to 9,336,000 foot-pounds of energy. An average central station economy is probably about 100 watt-hours per pound of such coal. One watt is equivalent to $\frac{1}{746}$ of a horse power; that is, to 44.2 foot-pounds per minute, or 2,652 foot-pounds in one hour. One hundred watt-hours per pound of coal would then represent 265,200 foot-pounds of energy produced from 9,336,000 foot-pounds—an efficiency of .0284. With a turbine of 93 per cent. efficiency, and a dynamo of 95 per cent., the combined efficiency is 88 per cent., which is over thirty times that just calculated.

The "watt-hours per pound of coal" equivalent to the efficiency of 88 per cent. is 3,098. The very best modern central station operated by steam power, rarely brings this figure above 200. Comparison is unnecessary. These are not wild, hypothetical fancies, but the efficiencies here stated are being daily attained in practice. Under such conditions the cost of electric current for lighting is less than one-fiftieth of a cent per lamp-hour (16 c. p.). This is cheaper than tallow.

Electric lighting in mines is by far the simplest and safest method of illumination. All switches and points of contact are encased in spark proof covers, making it impossible for the formation of a temporary arc during the breaking of the circuit to cause an explosion, in locations where such an event might otherwise be a possibility. The rules which the National Board of Underwriters have established for house wiring are, in certain respects, applicable to the conditions of mine service; and, in those respects, they should be observed. The ordinary voltage of incandescent lamps operated in parallel, is either 50 or 100. For the long distances covered by the requirements of most mines, the loss would be very large at these voltages. The system has therefore been adopted of connecting lamps in series clusters across mains of a sufficiently high voltage for reasonable economy. Thus five 50 volt lamps are connected in series across a 250 volt circuit, or five 100 volt lamps across a 500 volt circuit. On many street railways, the cars are lighted by ten 50 volt lamps in series with the line and the track, the difference of potential being here from 500 to 550, or about fifty volts per lamp. Another system is that of "series incandescent lighting," properly so called, in which lamps of especial design are operated on a series, constant current circuit, direct current being used. To supply direct current for this purpose from the polyphase current transmitted from the generators, a machine called a rotary transformer is utilized. This apparatus is practically a motor mounted on the same shaft with a generator. The alternating polyphase current from the main line runs the motor, which in turn runs a generator, the latter supplying direct current. The Westinghouse rotaries are standard apparatus of high efficiency. They are simple in construction and operation, and are in use to a very large extent for such purposes as that mentioned.

An objection to the method of lighting just mentioned, is the high voltage of the line necessary. One hundred 25 candle power lamps on a circuit of moderate length, may require a potential of 1000 volts, and the consequences of an accidental "ground" on such a circuit are apt to be very serious to the victim.

For lighting large open spaces, and in fact for any purpose where a light of intensity is required, the enclosed arc lamp is the most satisfactory. The efficiency of most of the enclosed arc lamps is at least four times that of the best of incandescent lamps; it is less fragile, and is absolutely safe, as the globe encloses the arc so as to make it perfectly air tight. These lamps take either direct or alternating current, and burn on 110-volt circuits. For circuits of considerable length, three can be connected across 330-volt mains, and the lamps are cheap, durable and w iterproof.

Much of the wiring in mine lighting is, of necessity, temporary, and all fixtures and lamps should be designed so as

to be easily connected and removed. The contrast in the facility of such removals between this and any other system of lighting, is greatly in favor of electricity.

Lamp voltages, as previously stated, are usually 50 (48-60), 100 (96-108), and 110 (108-120). Lamps have been made for potentials as high as 250 volts but not for practical purposes. The line voltages which are usually reckoned standard are:

House voltages	50, 110, 220	Low potentials
Line voltages	500, 1100, 2200	Commercial distribution potentials
	5000, 10000, 15000, 20000	Long distance transmission potentials.

Five hundred volts is considered dangerous, but voltage lower than this may be fatal under certain circumstances.

Wiring may be either overhead, the wires being supported by insulators or in an underground cable or conduit. The cable system is apt to be troublesome unless thoroughly protected from moisture, as there is difficulty in repairing (sometimes in locating) breaks. The cost of wiring for a power distributing system is small as compared to that of piping for steam or compressed air. This cost is usually based on the number of "outlets," or places where the line is tapped for power or light. It depends also upon the voltage and amount of current carried, the character and dryness of the soil or rock in which the mine is sunk, etc.

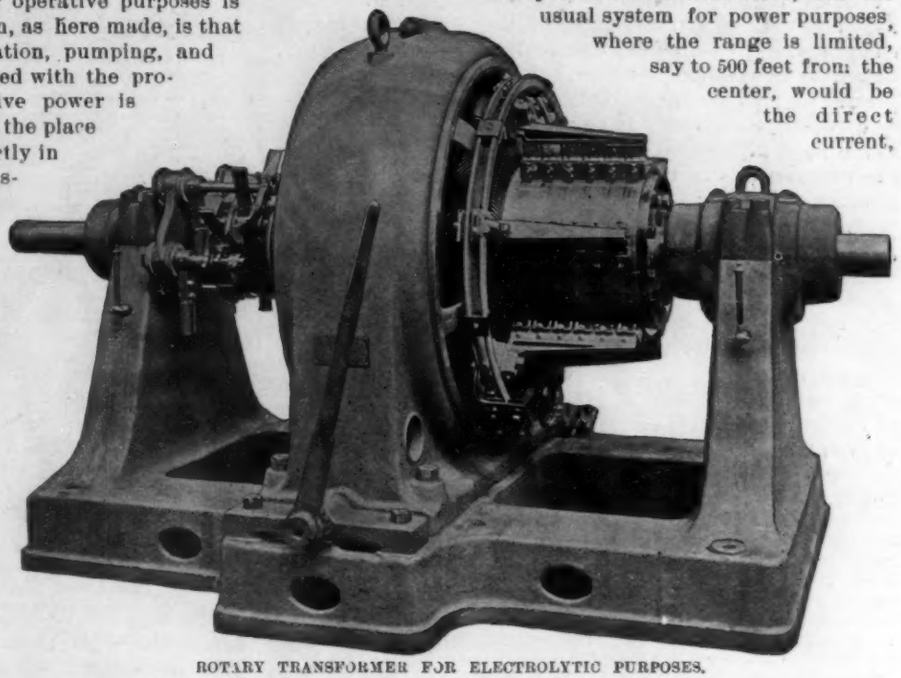
AUXILIARY POWER IN MINES.

The distinction between the two classes of auxiliary and operative power is one that is merely for purposes of convenience. The conditions governing the design of the electrical machinery in these fields are precisely the same, excepting that machinery for operative purposes is sometimes portable. The distinction, as here made, is that auxiliary power is used for ventilation, pumping, and other purposes not directly connected with the process of working the mine; operative power is that which operates the mine, taking the place of manual labor, and resulting directly in the output. The subject of power transmission in mines has been ably covered in the series of papers written by Mr. Rankin Kennedy, which, however, are more applicable to English operations than to those of this country. Mr. Cyrus Robinson, at the joint meeting of the Western Pennsylvania Central Mining Institute, and the Ohio Institute of Mining Engineers, June, 1896, set forth the advantages of electrical machinery, and concluded that the electrical system is superior, as a whole, to any other system of transmitting power. In view of the progress that has been made since that paper was read, the conclusion seems weak and trite. Affording as it does, a maximum of flexibility and simplicity, and rendering it possible to use successfully one generating plant to furnish power to all parts of the mines, and for all purposes, such as coal cutting, drilling, lighting, pumping, hoisting, haulage, fans, screens, conveyors, etc., the adavntages of the electrical system, with its consequent reduction in the cost of operating the plant, must be apparent at once to the mind of any business man. That this is the case is shown by the large number of mines in this country operated throughout by electrical machinery.

Progress in this direction has been less rapid in England. It is estimated that out of 212,000,000 tons of coal mined in Great Britain in 1895, not more than 750,000 tons were mined by machinery. During the year 1896, according to Mr. Robinson, over $1,000,000 worth of electrical machinery was installed in coal mines alone, in the United States. Fully 90 per cent. of this was for coal cutting machinery. In the development of the gold mines of British Columbia, electricity is playing an important part in the operation of drills, hoists, etc., the installations being usually in large units. One of the larger mines is supplied with a transmission system which runs a 300 kilowatt motor, which drives an air compressor with a capacity of forty drills. A 300 horse power induction motor is also used to run an electric hoist, on which the working load is eight tons.

Ventilating fans, blowers, etc., naturally come under the classification of auxiliary power. Perhaps in no application is the electric motor better adapted than for the rapid speed of a fan. For this service, the motor may be either belted or direct connected. A view of a fan belted to a Westinghouse motor is shown on page 22, while in pumping, the motor is on almost every occasion, geared down so as to get a suitably slow speed. Where the pump is designed for rapid work, a motor run by low frequency alternating current or by low voltage direct current, may be direct-connected. For the ordinary centrifugal pump, which is probably the cheapest and simplest, the common motor speed is suitable, as in the case of a ventilating fan, either belted or direct connected.

Modern progress in the design of electrical machinery has made it a matter of slight consequence, so far as the efficiency of the machines is concerned, what system of distribution is used. The various methods of distribution have been briefly mentioned heretofore, but the usual system for power purposes, where the range is limited, say to 500 feet from the center, would be the direct current, constant potential system, at a potential of about 200 volts. For mines covering a large acreage, alternating high potential current should be carried to the several shafts, and thence transformed down to 100 or 200 volts and distributed. If local conditions require direct current, a rotary transformer instead of a static transformer must be used. Direct current motors are made for either 110 (100), 220 (200), or 500



ROTARY TRANSFORMER FOR ELECTROLYTIC PURPOSES.

volts. These are the voltages commonly considered standard, and in planning the distribution, due regard should be paid to the fact.

OPERATIVE POWER IN MINES.

THE variety of uses to which power is applicable in the operations of mining are almost unlimited. Labor saving devices have been introduced more slowly in this class of work than in many other industries, for the reason that the nature of the labor is such as to require portable or semi-portable apparatus. Steam, water, and compressed air are noteworthy for their lack of portability. Electricity, however, has developed chiefly in that direction, and of all forces, is the most adaptable to temporary work.

The machinery of mining comprises an immense variety of tools, and in the different kinds of mining enterprises the variations are as great as in any different industries. There are the purely portable tools, the drills, picks, etc.; the manufacturing machinery, stamps and crushers; chemical apparatus, and a host of other classes of mechanisms by which time and money are saved.

For such portable tools as are used by each workman in his labor, most sources of power are rather a hindrance than a help. Clumsy piping, traps, drips, and drains, with the complication of pumping apparatus, are well calculated to make the victims curse the whole breed of so-called labor saving machinery. Electric power needs but the almost invisible, flexible, silent wire to carry on its work. Even in cases where the tools have been designed for some other source of power, the advantages of electricity have been so plainly seen by practical miners, that the effective motor has been called into play to supercede the wheezy, croupy compressor.

Such a substitution has been considered in a paper on "Coal Cutting Machinery," by Cyrus Robinson, M. E., published in "Mines and Minerals" of May, 1898. The system comprises an electrically operated portable compressor, driven by an electric motor, and the present form of compressed air pick machines. It is well known that in standard compressor plants a very large percentage of the loss is due to the necessity of cooling the air before it is discharged to the receiver, this in turn being followed by the troubles in freezing as the air and temperature are expanded in use. With the arrangement proposed, the air would be used at practically the same temperature obtained by compressing without cooling, and in use would be expanded down to a temperature slightly below that of the surrounding air; in this way an increase of efficiency would be obtained of at least 30 per cent. This in turn means that a compressor of about 30 per cent. less capacity would be required where the air is used without cooling. The designs for an equipment of this kind show that everything required for the operation of two pick machines can be mounted on a truck which could be easily pushed around by the machine runner and his helper, together with the machine itself, and would therefore not be any more cumbersome to handle than the standard breast machine. The advantages claimed for this arrangement when used in connection with electric plants are: No hand-mined coal; maximum efficiency from the breast machines, as they can be used entirely where the conditions are most favorable, and the pick machines used for room turning, robbing, and faulty work; larger yield of coal per acre; less timber for propping, as the work could be kept up much closer and sections of the mines worked out rapidly.

In the metallurgy of gold, the adaptability of the electric current for the cyanide or other electrolytic processes, has been well demonstrated. A type of machine like that illustrated on page 23 is used to supply the electrolytic current. The nature of the operation requires a very large current at a low voltage, hence the large brush area at the left or delivery side of the machine. This is a rotary transformer, being supplied with alternating current from high potential mains, through a static transformer as a mediary.

(Continuation in next number.)

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

ELECTRICAL SUPPLIES OF EVERY DESCRIPTION.

THE card of the John M. Klein Electrical Works appearing on one of the regular advertising pages, calls attention to one of the oldest and best established electrical supply houses on the Pacific Coast, and its reputation is one of thorough fairness and stability. Its standard line of business has for many years been in the direction of telephone and telegraph supplies, but of late it has been reaching out into the general electrical supply trade, until now it has a very extensive stock, including supplies for every branch of the electrical business.

Reference to specific features and appliances will be made from month to month in the advertising pages but at present it may be well to point out that among the recent valuable agencies acquired by John M. Klein's Electrical Works are those for the Jandus Electric Company of Cleveland, O., and for Partrick, Carter & Wilkins, successors to the Partrick & Carter Company of Philadelphia, which, for nearly two decades, has stood foremost in America in the manufacture of electrical house goods, annunciators, alarms, bells, etc. Of all the various lines of stock carried by Klein's Electrical Works none is more complete than the stock of house fittings of the Partrick, Carter & Wilkins Company.

The Jandus Electric Company is the manufacturer of the Jandus enclosed alternating current arc lamp, which is pleasing in design, thorough and reliable of workmanship, noiseless in operation, high in efficiency, and, above all, it is at all times, a perfectly reliable and satisfactory burner. As is the case with the Partrick, Carter & Wilkins goods, a large consignment of the Jandus arc lamps is always in stock, thus insuring promptness in filling orders, however large.

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